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CONTENTS

CONTENTS

CONTENTS

CONTENTS

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THE CHEMICAL COMPOSITION OF PHILIPPINE MUSHROOMS

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ELEVEN PLATES

The importance of mushrooms as an article of diet and of commerce is recognized everywhere, and the Philippines import large quantities of them from Japan and China. In view of the increasing use and importation of foreign mushrooms, it becomes important to know how to culture not only foreign species but also some of the important kinds which are found growing wild in many places of the Islands.

The culture and chemical composition of mushrooms have been studied abroad, but little similar work has been done in the Philippines. Vicencio (1917) reported on mushroom culture in the Philippines, but he gave only meager information about the native methods.

The senior author (1931) reported some analyses of Philippine mushrooms, with their different local names and a brief account of the edible and poisonous species. He also made certain suggestions for collecting wild mushrooms and important recommendations regarding the collection and sale of mushrooms in

order to prevent or reduce to the minimum the not few cases of mushroom poisoning which are reported from time to time from various parts of the Philippines.

The Philippines is especially noted for the number of its mushroom species, many of which, according to E. B. Copeland (1905) are edible. It is the object of this article to report the proximate chemical and inorganic composition of the commonest edible Philippine mushrooms in order to determine their food value.

The samples used in this study were collected in and around the vicinity of the College of Agriculture, University of the Philippines, Los Baños, Laguna. The fresh samples collected were at once submitted to the Department of Plant Pathology for identification. Fresh specimens were also placed in preserving fluid consisting of hydrochloric acid, alcohol, and water. This preserving fluid was found to be satisfactory in preserving the specimens for identification purposes. To Mr. Jose M. Mendoza, mycologist of the Bureau of Science, who has kindly consented to verify the identification of specimens reported in this study, the authors desire to express their great appreciation. Some imported mushrooms from China, Japan, and France were analyzed and compared, as to chemical composition, with Philippine species.

Species of mushrooms studied

1. *Psaliota* (*A.*) *campestris* Fr.; imported variety in cans (champinion).
   a. Solid portion.
   b. Liquid portion.
2. *Psaliota* (*A.*) *campestris;* Philippine variety A.
3. *Psaliota* (*A.*) *merrillii* Copel. B.
4. *Psaliota* (*A.*) *perfuscus* Copel.; fairy ring mushroom or lawn mushroom.
5. *Auricularia auricula-judae* (Linn.) Schroet.; taiñgang-daga (Tag.), imported from China.
6. *Auricularia* sp.
7. *Hirneola affinis* (Jungh.) Bres.
8. *Auricularia polytricha* Montagne.
9. *Collybia albuminosa* (Berk.) Petch.; cabuten punsó (Tag.), óong ti bontón (Il.).
10. *Collybia* sp.; mamarang (Tag.), man-nagado (Il.).
11. *Cortinellus* sp.; from China.
12. *Cortinellus Shiitake* Schroet.; imported from Japan.
13. *Lepiota cepaestipes* Fr.
14. *Lepiota chlorospora* Copel.; payong aias (Tag.).
15. *Lentinus squarrosulus* Mont.; kulat-kulat (Tag.).
16. *Lentinus exilis* Klotz.; kulat-kulat (Tag.).

Species of mushrooms studied—Continued

17. *Pleurotus ostreatus* Jacq.; an-andáp (Il.), alitáp-táp (Tag.).
18. *Lentinus* sp.; curly; kulot-kulot (Tag.).
19. *Marasmius* sp.; small, orange, umbrella shaped.
20. *Lentinus* sp.; kulat-kulat (Tag.).
21. *Pleurotus opuntiae* (Dur. et Lev.) Sacc.
22. *Pleurotus limpidus* Fr.; an-andáp (Il.), alitáp-táp (Tag.).
23. *Pleurotus* sp.; an-andáp (Il.), alitáp-táp (Tag.).
24. *Lycoperdon lilacinum* Copel.; puffball; para-para (Il.).
25. *Volvaria esculenta* Bres.; kabuteng saguing, kabuting guiniican (Tag.).
26. *Galera* sp.
27. *Pholiota* sp.
28. *Stereum* sp.

METHODS OF ANALYSIS

Excepting for those which were modified by the senior author (1931), the Official and Tentative Methods of Analyses (1931) were used.

The results are given in Table 1. These figures are averages of at least two concordant determinations. The moisture content, as can be seen in the table, varies from 88.03 per cent for *Pleurotus opuntiae* A to 98.02 per cent for *Hirneola affinis.* (white gelatinous), giving an average of 87.30 per cent for the Philippine mushrooms studied. The canned mushrooms contain 92.58 per cent moisture for the solid portion and 97.60 per cent for the liquid portion.

To secure a better idea of the differences between the Philippine mushrooms studied and the imported species, the results in Table 1 were converted into terms of dry basis. These data are given in Table 2. It can be seen from the table that for Philippine mushrooms analyzed the ash varies from 4.24 per cent for *Lentinus squarrosulus* to 25.72 per cent for *Collybia* sp. (mamarang), giving an average of 11.19 per cent. For the imported mushrooms, excluding the canned species, it varies from 6.05 per cent for *Cortinellus Shiitake* Schroet. to 9.41 per cent for *Auricularia auricula-judae* (Linn.) Schroet. giving an average of 7.88 per cent. From these figures we see that there is a wide range in the mineral content of Philippine mushrooms, fourteen of twenty-three species analyzed having a higher mineral content than the imported varieties and the rest about the same values. The canned mushrooms contained 18.60 per cent as for the solid portion and 55 per cent for the liquid portion. These exceptionally hi[illegible] figures were found on analysis to be due mostly to the added salt in the preserving fluid.

The protein content varies from 6.04 per cent of *Auricularia polytricha* to 65.69 per cent for *Lycoperdon lilacinum* Copel. (puffballs), giving an average of 28.35 per cent for the Philippine mushrooms analyzed. Protein in the imported varieties varies from 11.59 per cent for *Auricularia auricula-judae* (Linn.) Schroet. from China to 27.10 per cent for *Cortinellus Shiitake* Schroet. from Japan, giving an average of 17.72 per cent for imported materials. The canned mushrooms gave 62.40 per cent protein for the solid portion and 15.83 per cent for the liquid portion. From the table we can see that four species of the Philippine mushrooms studied contain less protein than the imported mushrooms, eight species contain about the same amount, and the rest have higher protein contents. On the average, the Philippine mushrooms studied have a higher protein content than the imported species.

The fat content of Philippine mushrooms analyzed varies from 0.59 per cent for *Lentinus* sp. (curly) to 20.63 per cent for *Volvaria esculenta* Bres. (kabuteng saguing), giving an average of 5.37 per cent. The imported mushrooms contain from 0.86 per cent for *Pleurotus ostreatus* from China to 2.40 per cent for *Cortinellus Shiitake* Schroet. from Japan, giving an average of 1.63 per cent. The canned mushrooms gave 5 per cent fats for the liquid portion and 0.40 per cent for the solid portion.

The crude-fiber content of Philippine mushrooms varies from 6.96 per cent for *Psaliota (A.) merrillii* B to 36.83 per cent for mushrooms from a coffee plantation, giving an average of 15.08 per cent, whereas the same constituent varies from 6.92 per cent for *Auricularia auricula-judae* (Linn.) Schroet. from China to 14.72 per cent for *Cortinellus* sp. (Chinese mushrooms), giving an average of 10.87 per cent for the imported species. The canned mushrooms gave a crude-fiber content of 12.40 per cent.

The nitrogen-free extract for Philippine mushrooms varies from 2.35 per cent for *Pleurotus limpidus* B to 66.07 per cent for *Auricularia politricha* (brown top, white bottom), giving an average of 38.77 per cent for Philippine species. For the imported mushrooms it varies from 50.40 per cent for *Cortinellus Shiitake* Schroet. from Japan to 20.65 per cent for *Pleurotus ostreatus* from China, giving an average of 62.64 per cent nitrogen-free extract for the imported species. The canned mushroom gave 24.17 per cent nitrogen-free extract for the liquid portion and 6.20 per cent for the solid portion. In this constituent the Philippine mushrooms are lower than those of the imported species.

The calorific or fuel value of Philippine mushrooms varies from 1,923 calories per kilo to 4,170 calories per kilo of *Volvaria esculenta* Bres., giving an average of 3,249 calories per kilo. For the imported species it varies from 3,292 calories per kilo for *Cortinellus* sp. (Chinese mushroom) to 3,539 for *Pleurotus ostreatus* from China, giving an average of 3,447 calories. The canned species gave a calorific value of 2,850 calories per kilo for the solid and 2,105 calories per kilo for the liquid portion.

The inorganic analysis of the ash constituents of Philippine species reveal interesting facts. The ash constituents determined are SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, P_2O_5, S, and Cl. The results are given in Table 3. Averaging the figures for Philippine species, imported air dry, and canned species, a comparison of the ash constituents is given in Table 4. From these figures we find that, on the average, Philippine mushrooms are lower in silica, magnesium, sodium, potassium, and sulphur content than the imported mushrooms, but higher in iron, aluminum, calcium, and phosphorus. The canned mushrooms are exceptionally high in iron, sodium, and chlorine.

SUMMARY AND CONCLUSIONS

1. Twenty-three species of Philippine mushrooms and five imported species were analyzed.

2. On the average the Philippine mushrooms studied were found to be higher in mineral content, protein, and fat than the imported mushrooms but lower in crude fiber and carbohydrates.

3. With the exception of six species the Philippine mushrooms studied have about the same food value as the imported species and some have even more.

4. Six of the widely known and used varieties; namely, *Psaliota* (*A.*) *campestris*, Philippine variety A, *Psaliota* (*A.*) *merrillii* Copel. B, *Hirneola affinis* (white gelatinous), *Auricularia polytricha* (brown top and white bottom), *Collybia albuminosa* (Berk.) Petch, *Lycoperdon lilacinum* Copel. (puffball), and *Volvaria esculenta* Bres. (kabuteng saguing), have higher food value than the imported species.

5. Canned mushrooms have low calorific value compared with many of the Philippine species studied.

6. On the average, the Philippine mushrooms studied are higher in iron, calcium, and phosphorus content than the imported mushrooms.

7. Canned mushrooms are exceptionally high in iron and sodium chloride content.

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TABLE 1.—*The proximate chemical composition of Philippine and imported mushrooms (fresh basis)*

Kind	Moisture	Ash	Proteins N×6.25	Fats (ether extract)	Carbohydrates		Calorific value per kilo
					Crude fiber	N. F. E.	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	
1. *Psaliota (A.) campestris* Fr.; imported variety in cans (champinion):							
a. Solid portion	92.58	1.38	4.63	0.03	0.92	0.46	211
b. Liquid portion	97.60	1.32	0.38	0.12		0.58	51
2. *Psaliota (A.) campestris*; Philippine variety A	78.30	1.66	10.13	1.37	2.02	6.52	810
3. *Psaliota (A). merrillii* Copel. B	89.02	1.09	5.36	0.17	0.76	3.60	383
4. *Psaliota (A.) perfuscus* Copel.; fairy ring mushroom or lawn mushroom	90.60	1.02	4.71	0.20	1.04	2.43	311
5. *Auricularia auricula-judae* (Linn.) Schroet.; taiñgang-daga (Tag.), imported from China	16.40	7.87	9.69	1.22	5.79	59.03	2,931
6. *Auricularia* sp.	89.07	0.51	0.66	0.91	2.16	6.69	386
7. *Hirneola affinis* (Jungh.) Bres.	98.02	0.22	0.19	0.27	0.23	1.07	77
8. *Auricularia polytricha* Montagne	90.45	0.57	0.60	0.93	1.14	6.31	370
9. *Collybia albuminosa* (Berk.) Petch.; cabuteng punsó (Tag.), óong ti bontón (Il.)	89.93	0.79	2.96	0.40	0.81	5.11	368
10. *Collybia* sp.; mamarang (Tag.), man-nagado (Il.)	95.18	1.24	0.32	0.20	0.69	2.37	129
11. *Cortinellus* sp.; from China	19.49	4.87	20.82	2.36	10.89	40.57	2,777
12. *Cortinellus Shiitake* Schroet.; imported from Japan	18.37	5.30	15.29	0.97	12.02	48.05	2,687
13. *Lepiota caepaestipes* Fr.	79.19	2.02	4.81	0.60	2.41	10.97	703
14. *Lepiota chlorospora* Copel.; payong ajas (Tag.)	91.82	1.08	4.38	0.10	0.79	2.33	284
15. *Lentinus squarrosulus* Mont.; kulat-kulat (Tag.)	70.77	1.56	2.44	0.99	6.33	17.91	926
16. *Lentinus exiles* Klotz.; kulat-kulat (Tag.)	71.71	1.20	4.52	0.60	9.19	12.78	765
17. *Pleurotus ostreatus* Jacq.; an-andáp (Il.), alitáp-táp (Tag.)	10.65	5.88	12.04	0.86	7.44	63.13	3,162
18. *Lentinus* sp.; curly; kulat-kulat (Tag.)	61.88	0.97	1.56	0.05	1.44	4.30	245
19. *Marasimius* sp.; small, orange, umbrella shaped	9.35	1.55	3.09	0.76	1.99	3.26	831
20. *Lentinus* sp.; kulat-kulat (Tag.)	0.26	1.13	3.57	0.40	3.39	11.25	645
21. *Pleurotus opuntiae* (Dur. et Lev.) Sacc.	68.03	5.04	4.07	0.78	2.44	19.64	1,045
22. *Pleurotus limpidus* Fr.; an-andáp (Il.), alitáp-táp (Tag.)	92.98	0.38	3.88	0.66	1.94	0.16	227
23. *Pleurotus* sp.; an-andáp (Il.), alitáp-táp (Tag.)	94.71	0.73	1.00	0.05	0.86	2.65	154
24. *Lycoperdon lilacinum* Copel.; puffball; para-para (Il.)	89.39	0.82	6.67	0.79	1.30	0.73	389
25. *Volvaria esculenta* Bres.; kabuteng saguing, kabuteng guiniican (Tag.)	91.13	1.18	4.35	1.83	0.99	0.52	370
26. *Galera* sp.	93.17	1.31	1.71	0.47	0.87	2.47	215
27. *Pholiota* sp.	91.50	1.07	2.94	0.49	3.13	0.87	202
28. *Sterum* sp.	92.16	1.80	1.66	0.09	2.48	1.81	151

TABLE 2.—*The proximate chemical composition of Philippine and imported mushrooms (dry basis)*

Kind	Moisture	Ash	Proteins N×6.25	Fats (ether extract)	Carbohydrates: Crude fiber	Carbohydrates: N. F. E.	Calorific value per kilo
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	
1. *Psaliota (A.) campestris* Fr.; imported variety in cans (champinion):							
a. Solid portion	92.58	18.60	62.40	0.40	12.40	6.20	2,850
b. Liquid portion	97.60	55.00	15.83	5.00	....	24.17	2,105
2. *Psaliota (A.) campestris*; Philippine variety A	78.30	7.65	46.68	6.31	9.31	30.05	3,753
3. *Psaliota (A.) merrillii* Copel. B	89.02	9.93	48.85	1.51	6.96	32.75	3,486
4. *Psaliota (A.) perfuscus* Copel.; fairy ring mushroom or lawn mushroom	90.60	10.85	50.10	2.10	11.04	25.91	3,312
5. *Auricularia auricula-judae* (Linn.) Schroet.; taiñgang-daga (Tag.), imported from China	16.40	9.41	11.59	1.46	6.92	70.62	3,506
6. *Auricularia* sp.	89.07	4.67	6.04	8.33	19.76	61.20	3,532
7. *Hirneola affinis* (Jungh.) Bres.	98.02	11.11	9.60	13.64	11.62	54.03	3,877
8. *Auricularia polytricha* Montagne	90.45	5.97	6.28	9.74	11.94	66.07	3,872
9. *Collybia albuminosa* (Berk.) Petch.; cabuteng punsó (Tag.), óong ti bontón (Il.)	89.93	7.85	29.44	3.97	8.09	50.65	3,653
10. *Collybia* sp.; mamarang (Tag.) man-nagado (Il.)	95.18	25.72	6.72	4.22	14.38	48.96	2,675
11. *Cortinellus* sp.; from China	19.49	6.05	27.10	2.93	13.52	10.40	3,450
12. *Cortinellus Shiitake* Schroet.; imported from Japan	18.37	6.49	18.73	1.19	14.72	58.87	3,292
13. *Lepiota cepaestipas* Fr.	79.19	9.71	23.11	2.86	11.58	52.74	3,376
14. *Lepiota chlorospora* Copel.; payong ajas (Tag.)	91.32	12.44	50.41	1.19	9.05	26.87	3,281
15. *Lentinus squarrosulus* Mont.; kulat-kulat (Tag.)	70.77	5.34	8.75	3.39	21.66	61.26	3,170
16. *Lentinus exilis* klotz.; kulat-kulat (Tag.)	71.71	4.24	15.97	2.12	32.48	45.19	2.705
17. *Pleurotus ostreatus* Jack.; an-andáp (Il.), alitáp-táp (Tag.)	10.65	6.58	13.48	0.96	8.33	70.65	3,537
18. *Lentinus* sp.; curly; kulat-kulat (Tag.)	19.68	11.16	18.75	0.59	17.19	52.31	2,968
19. *Marasimius* sp.; small, orange, umbrella shaped	89.35	14.55	29.06	7.14	18.65	30.60	3,110
20. *Lentinus* sp.; kulat-kulat (Tag.)	80.26	5.72	18.09	2.03	17.17	56.99	7,171
21. *Pleurotus opuntiae* (Dur. et Lev.) Sacc.	58.03	15.76	12.72	2.37	7.63	61.52	3,264
22. *Pleurotus limpidus* Fr.; an-andáp (Il.), alitáp-táp (Tag.)	92.98	5.34	55.27	9.40	27.64	2.35	3,237
23. *Pleurotus* sp.; an-andáp (Il.), alitáp-táp (Tag.)	94.71	13.80	18.90	0.95	16.26	50.09	2,917
24. *Lycoperdon lilacinum* Copel.; puffball; para-para (Il.)	99.39	7.73	65.59	7.45	12.25	6.86	3,668
25. *Volvaria esculenta* Bres.; kabuteng saguing, kabuteng guinilcan (Tag.)	91.13	13.30	49.04	20.63	11.16	5.87	4,170
26. *Galera* sp.	93.17	19.18	25.03	6.88	12.81	36.10	3,146
27. *Pholiota* sp.	91.50	12.59	34.57	5.78	36.83	10.24	2,374
28. *Sterum* sp.	92.16	22.96	21.13	1.18	31.63	23.09	1,923

TABLE 3.—*Inorganic constituents of mushrooms based on ash*

Kind	Ash, dry basis	Inorganic constituents based on ash										
		SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	S	Cl	Total
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Kabuteng punsó; *Collybia albuminosa*	7.85	14.34	7.10	0.95	3.86	5.04	9.10	17.33	39.92	1.35	trace	93.99
Kabuteng saguing; *Volvaria esculenta*	13.20	15.23	4.47	0.99	2.35	0.92	15.37	24.76	30.14	1.42	3.85	99.50
Puffballs; *Lycoperdon lilacinum*	7.73	5.84	1.50	1.19	1.76	1.61	9.46	29.29	48.01	0.62	trace	99.28
Shiitake; *Cortinellus Shiitake*	6.05	9.28	5.69	0.71	2.73	6.77	24.04	24.82	19.07	3.91	1.20	98.22
Chinese mushroom; *Cortinellus* sp.	6.49	15.17	6.07	0.33	3.59	7.05	21.17	27.37	16.41	2.21	trace	99.37
Kulat-kulat; *Lentinus exilis*	5.24	11.07	6.44	0.75	3.51	1.89	21.38	29.65	22.45	1.19	trace	98.13
Taiñgang daga; *Auricularia* sp.	4.67	9.04	12.65	2.33	11.05	7.57	6.62	17.77	29.89	2.17	trace	99.09
French mushroom; *Psaliota (A.) campestris*, liquid [a]	55.00	2.25	0.30	30.45	2.34	1.00	40.30	3.41	5.15	2.50	([b])	....
French mushroom; *Psaliota (A.) campestris*, solid	18.60	8.96	7.91	6.22	3.11	0.89	42.58	4.02	8.22	2.08	([b])	....
Mushroom from coffee plantation; *Pholiota* sp.	12.59	4.01	4.01	9.73	12.42	1.02	23.64	5.44	33.04	2.03	2.74	98.08
Payong-ajas; *Lepiota chlorospora;* poisonous	12.44	3.35	14.88	10.05	4.19	1.52	20.40	6.98	33.19	2.53	1.15	98.24
Lepiota cepaestipes; poisonous	9.71	0.92	9.61	5.03	0.91	3.14	13.59	27.49	33.19	2.51	([b])	....
Marasmius sp.; small, orange, umbrella shaped	14.55	16.24	7.91	3.71	3.09	1.35	20.30	21.50	22.75	1.95	1.57	100.37
Psaliota (A.) campestris; Philippine variety	9.93	2.52	5.84	1.84	6.14	0.67	33.21	14.62	27.33	1.39	6.45	100.01
Kulat-kulat; *Lentinus* sp.	5.72	14.41	8.66	13.88	2.11	2.94	6.73	18.33	24.77	1.03	([b])	....

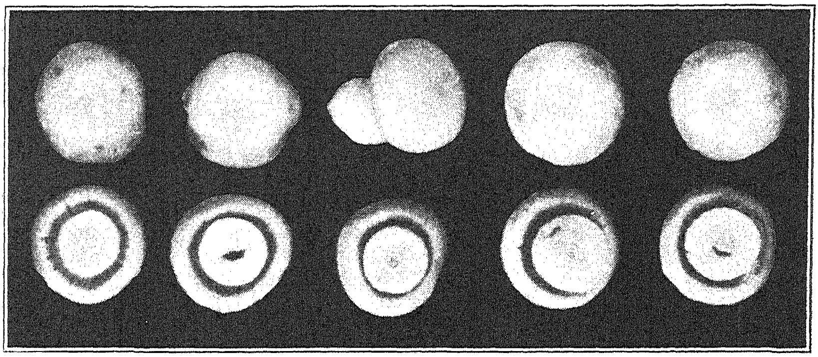
[a] Imported canned mushrooms from France.

[b] Not determined.

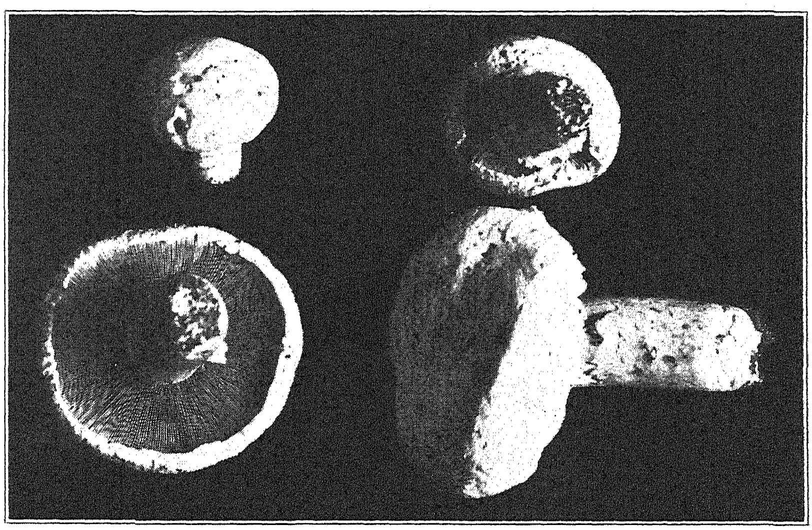
TABLE 4.—*Ash constituents of the different kinds of mushrooms (averages)*

Constituent	Philippine	Imported	Canned
	Per cent	*Per cent*	*Per cent*
SiO_2	8.82	12.23	5.61
Al_2O_3	7.55	5.88	4.11
Fe_2O_3	4.59	1.52	18.34
CaO	4.65	3.16	2.73
MgO	2.52	6.91	0.95
Na_2O	16.35	22.61	41.44
K_2O	19.38	26.20	3.72
P_2O_5	31.36	17.74	6.69
S	1.65	3.06	2.29

ILLUSTRATIONS

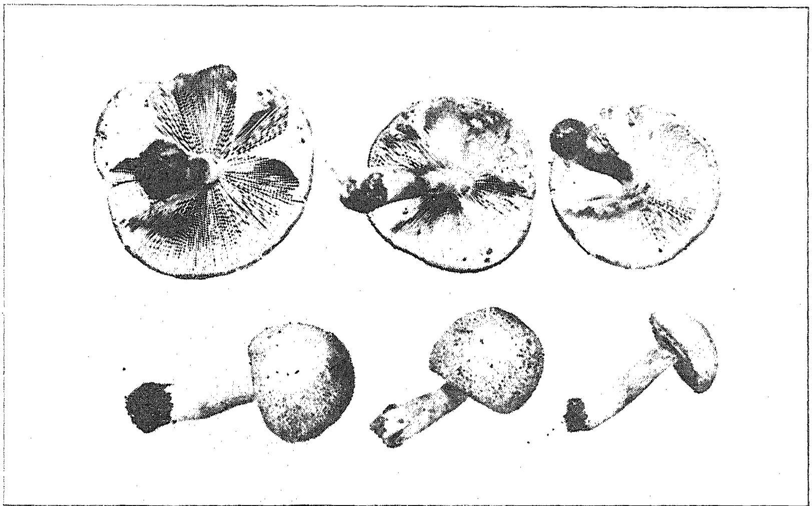


(*a*) Psaliota (A.) campestris Fr.

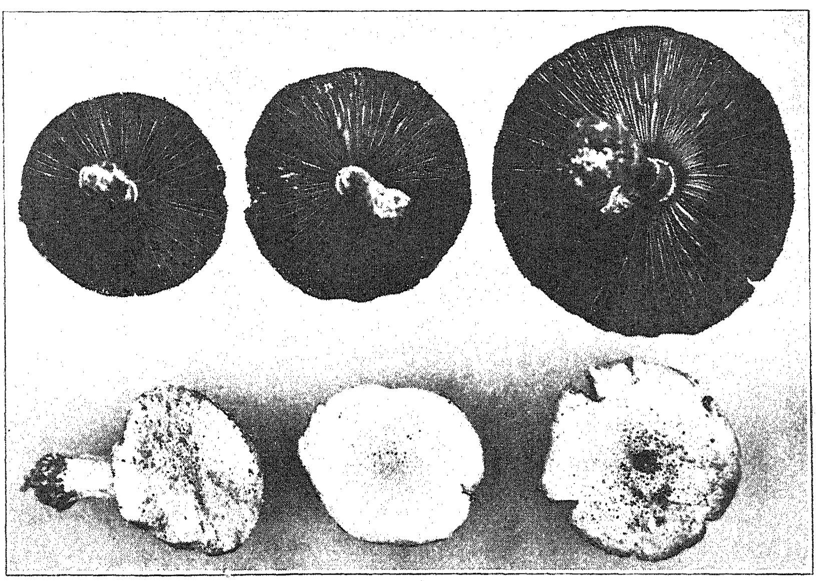


(*b*) Psaliota (A.) campestris, Philippine variety A.

PLATE I.

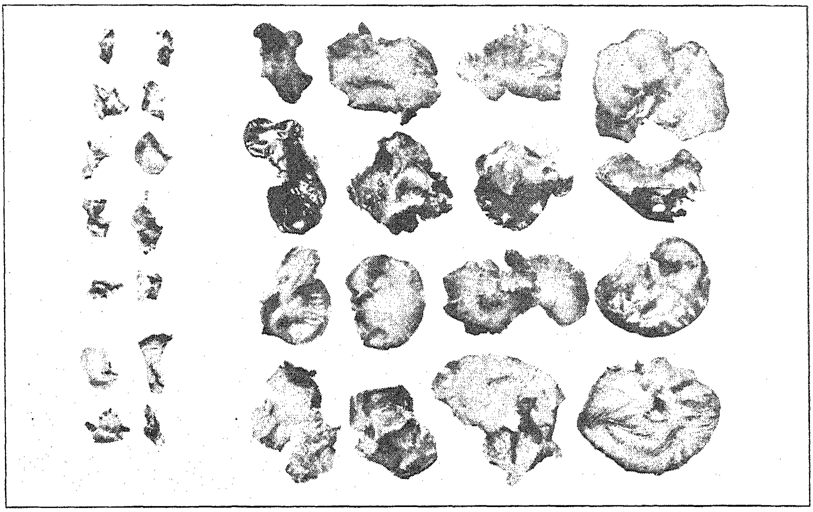


(*a*) Psaliota (A.) merrillii Copel. B.

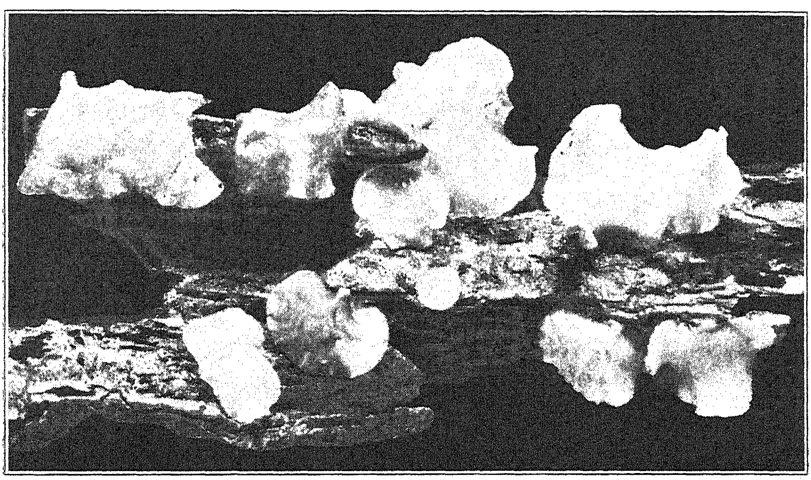


(*b*) Psaliota (A.) perfuscus Copel.

PLATE II.

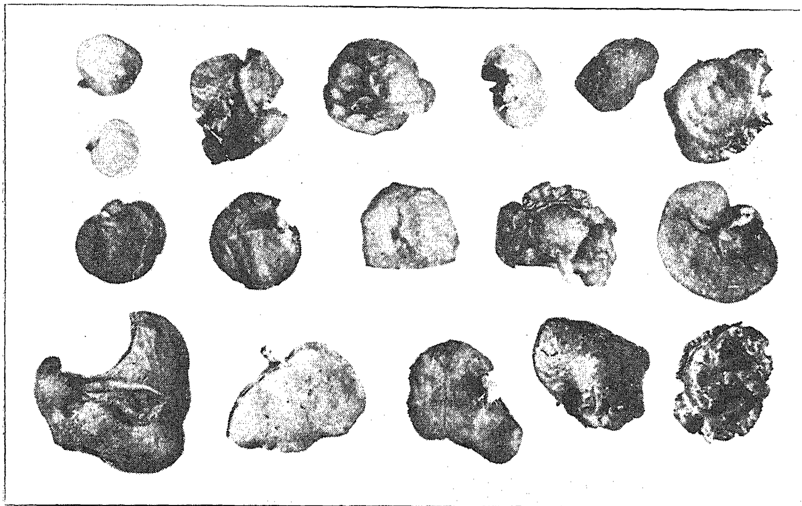


(*a*) Auricularia auricula-Judae (Linn.) Schroet. imported from China.



(*b*) Hirneola affinis (Jungh.) Bres.

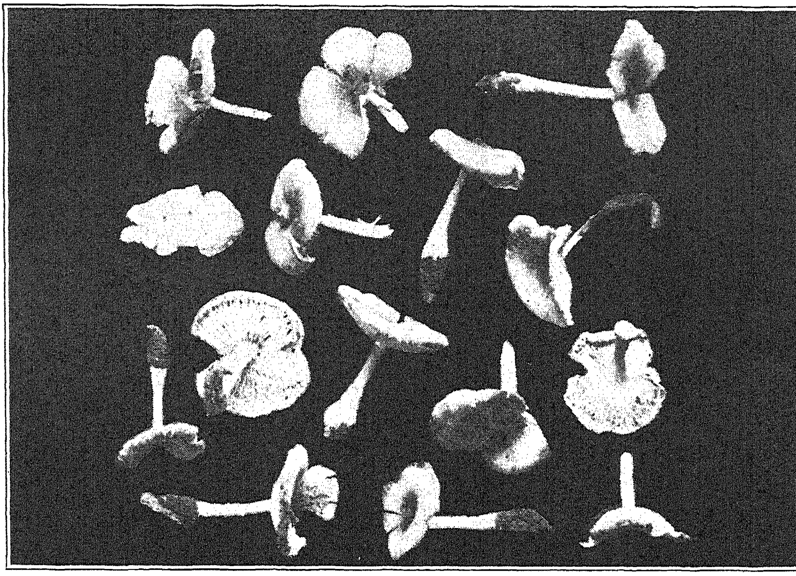
PLATE III.



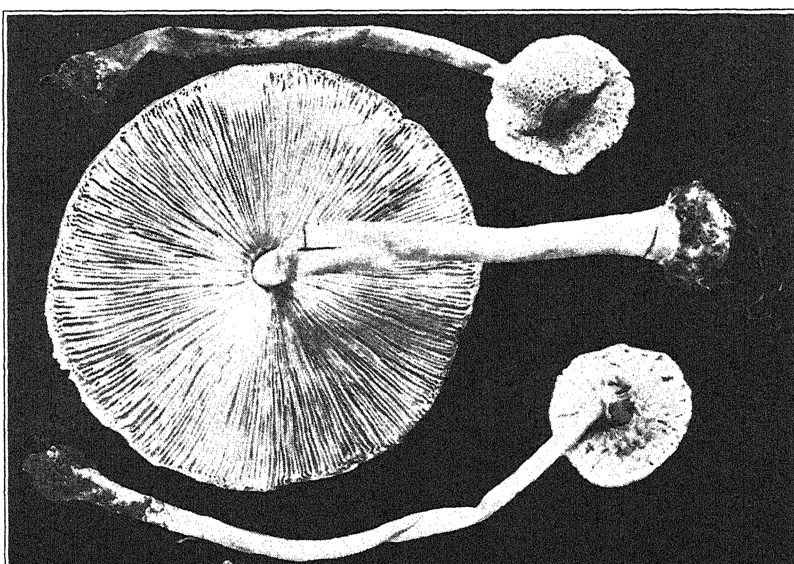
(*a*) Auricularia polytricha Montagne.

([illegible]) Collybia albuminosa (Berk.) Petch.

PLATE IV.

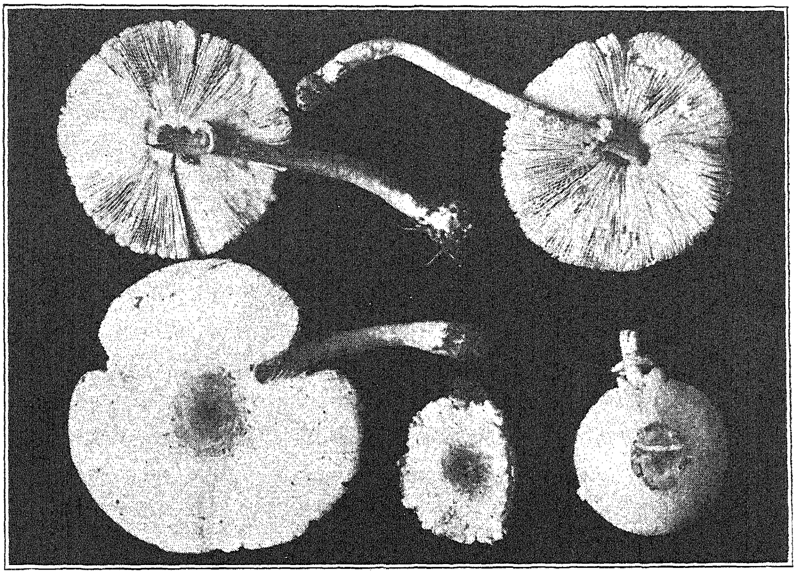


(*a*) Collybia sp. (mamarang).



(*b*) Lepiota cepaestipes Fr.

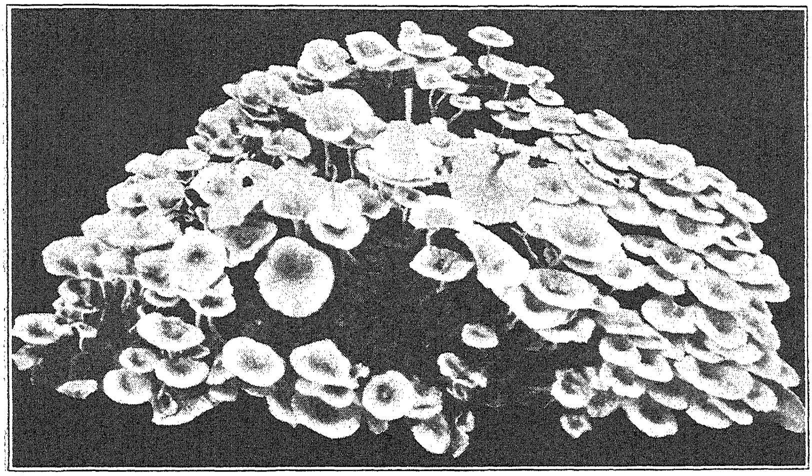
PLATE V.



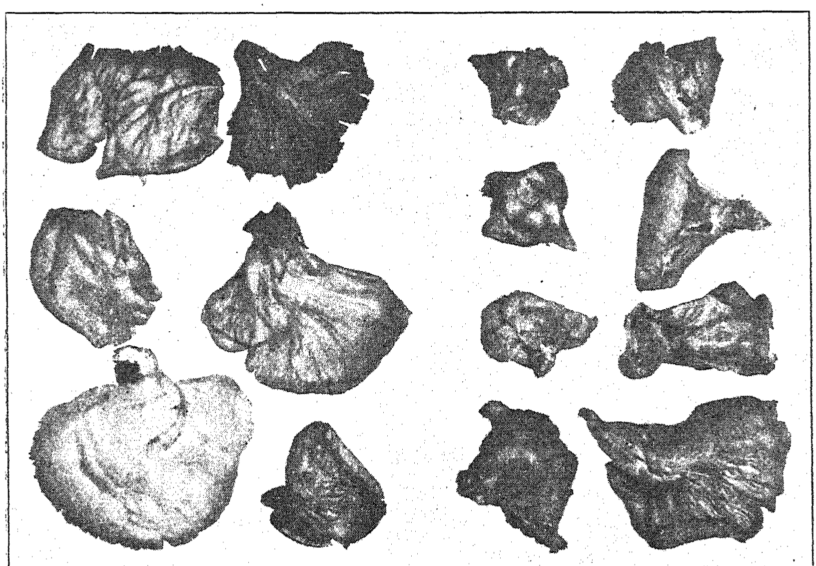
(*a*) Lepiota chlorospora Copel. (payong ajas).

(*b*) Lentinus exilis Klotz.

PLATE VI.

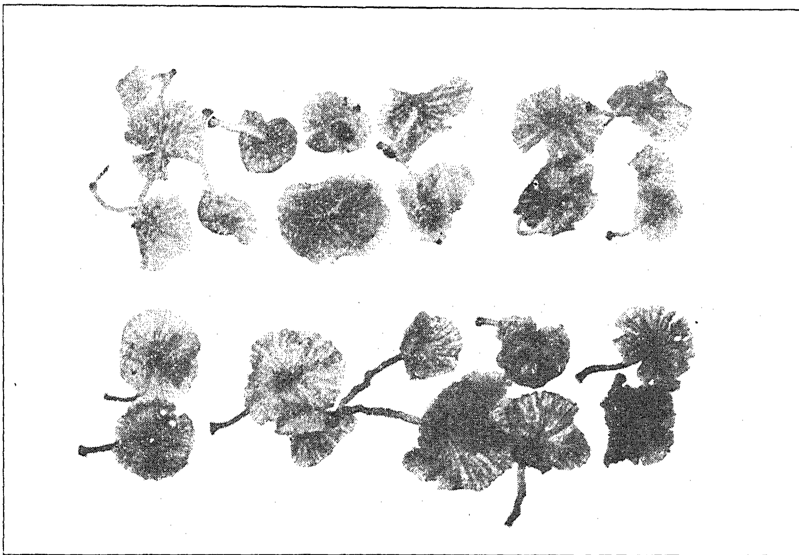


(*a*) Lentinus squarrosulus Mont.

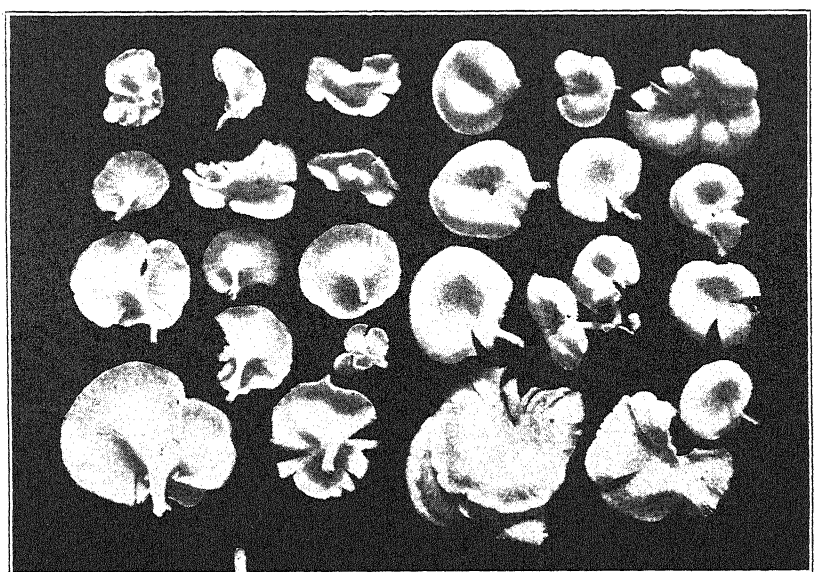


(*b*) Pleurotus ostreatus Jacq.

PLATE VII.

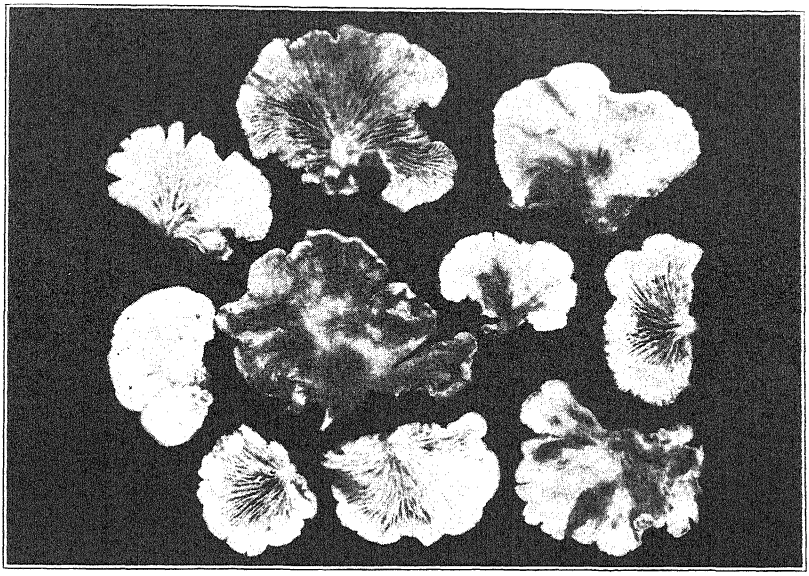


(*a*) Marasmius sp.

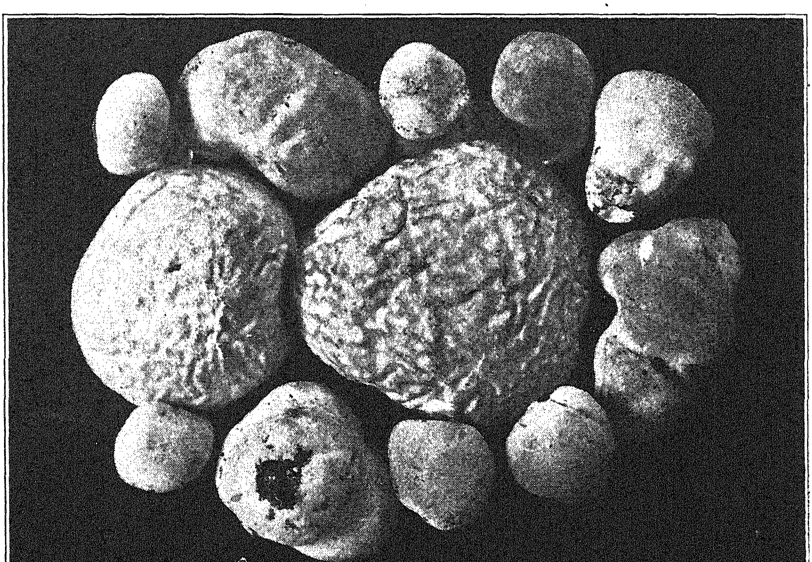


(*b*) Lentinus sp.

PLATE VIII.

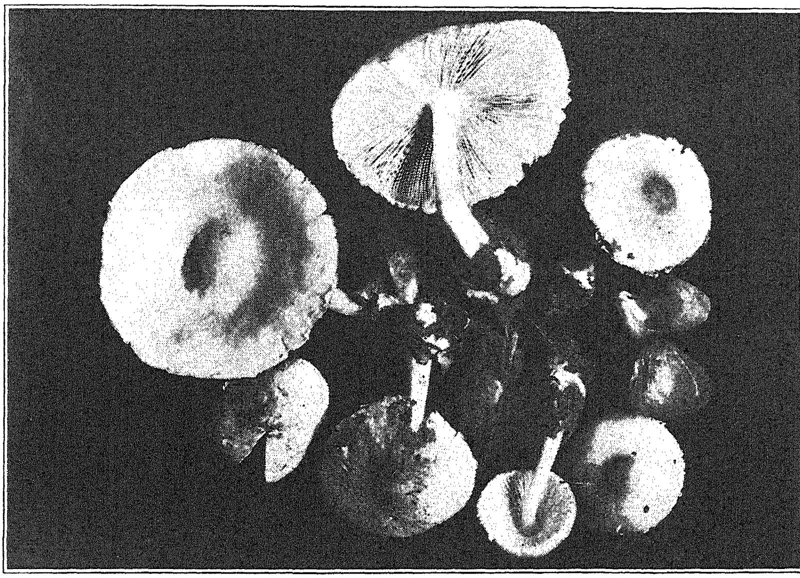


(*a*) Pleurotus opuntiae (Dur. et Lev.) Sacc. A.

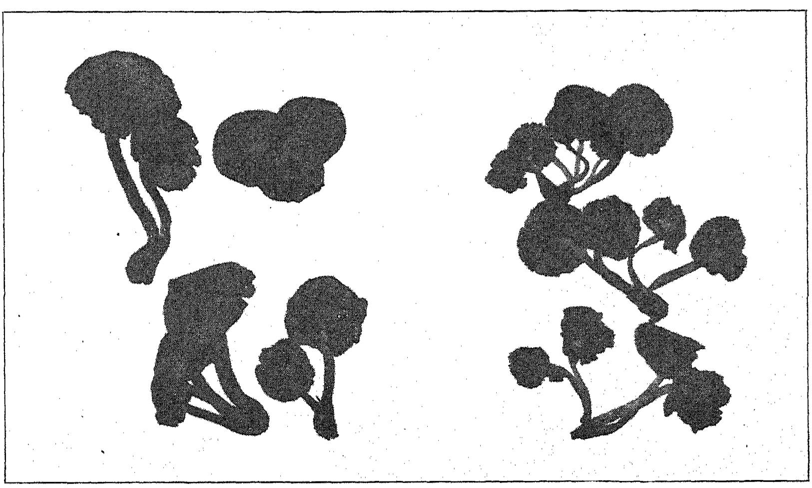


(*b*) Lycoperdon lilacinum Copel.; puffballs.

PLATE IX.

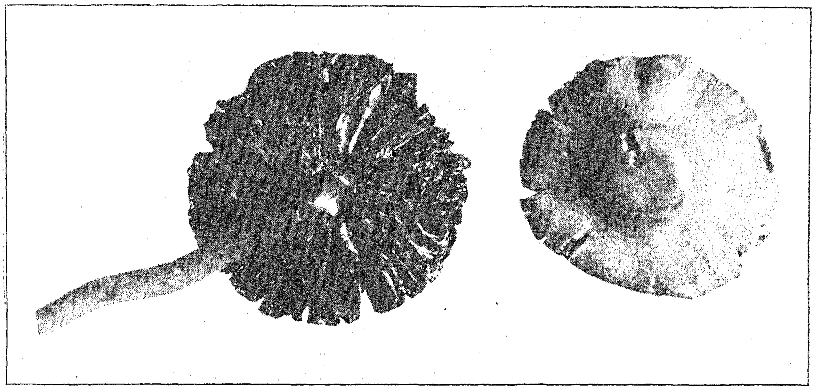


(*a*) Volvaria esculenta Bres.; kabuteng saguing.

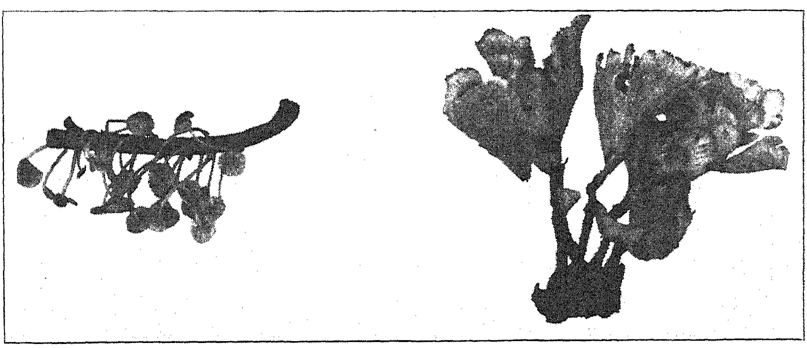


(*b*) Galera sp. from dead coconut tree.

PLATE X.



(a) Pholiota sp. from coffee plantation.



(b) Stereum sp. from rotten wood buried in the ground.

PLATE XI.

THE VALUE OF PHILIPPINE FRUITS AND VEGETABLES FOR THE PREPARATION OF FERMENTED AND UNFERMENTED PICKLES

By F. T. ADRIANO, A. VALENZUELA, and D. S. SANTOS
Of the Bureau of Plant Industry, Manila

TWO PLATES

Pickling in general is defined as the preservation of food in brine or in vinegar with or without bacterial fermentation. The term "pickle" as used in this country refers to two distinct kinds—the first to the so-called native, quick-processed or unfermented variety and the other to the more expensive, imported, and fermented kind. Many home attempts at preparing fermented pickles such as mangoes and other fruits fail because of lack of proper knowledge of the subject. The softening of salted (*burong*) mango, radish, and other fruits and vegetables as commonly prepared in the homes is well known.

The manufacture of pickles is an important food industry. It is a well-known fact that while the preservation of vegetables and fruits in pickled form began as a household art, yet at present a great amount of the world's supply of pickles is produced in commercial plants. This is due to the great demand for this food product among all classes of people. The Philippines, according to reports of the Bureau of Customs, imports annually from two to three hundred thousand pesos worth of pickled fruits and vegetables.

Most of our fruits and vegetables are seasonal and in some parts of the Islands where they are produced in large quantities, the farmers, for lack of good markets and proper knowledge of utilization, are forced to sell them at very low prices, or else feed them to animals or just throw them away as waste. However, after the season, these same materials can only be procured at exorbitant prices. If proper means of preserving these fruits and vegetables can be found, much waste will be stopped and a more equable distribution of the products throughout the year and a more uniform range of prices will result. One of these means is the pickling of vegetables and fruits by suitable methods.

In the Philippine little is yet known and done about the preparation of fermented pickles from fruits and vegetables and it is for this reason that the present work is being carried on.

We have a very long list of vegetables and fruits which can be turned into attractive and good quality fermented pickles just as good if not better than the imported kinds.

If proper methods of pickling become generally known, we can not only decrease our imports on this product, but we shall also encourage the planting of more fruits and vegetables. The food value of these plant products is already well known.

GENERAL PRINCIPLES IN PICKLING

The spoiling of fruits and vegetables is not due directly to the action of air or of heat and is not simply a physical change, but to the growth of certain microscopic living organisms or bacteria, of which there are many kinds.

Many of the vegetables as they come from the field have on their surfaces both lactic acid bacteria and other organisms capable of causing spoiling. Brine or salt is added to vegetables or fruits in pickling in order to inhibit microörganisms capable of causing spoiling and to promote the growth and multiplication of the desirable lactic acid bacteria as well as to improve the flavor and texture of the resulting pickle. Lactic acid bacteria can grow in certain concentrations of salt and in fact, the presence of proper amounts is necessary for their proper growth and development. The brine extracts the vegetable juices which serve as foods for the lactic acid bacteria. The lactic acid produced and the salt added preserve the product, provided that the air is excluded. In the presence of air, however, aërobic microörganisms develop, and destroy the acid and as a result putrefaction takes place.

Exclusion of the air after lactic fermentation is complete is an essential part of the process.

MATERIALS AND EQUIPMENT USED IN PICKLING

MATERIALS

Water.—Soft water is best for pickling. Hard water should not be used, especially for fermented pickles, as the presence of large quantities of calcium and other salts found in many natural waters prevents the proper lactic acid formation, thus

interfering with the curing process. Iron in large amounts is also objectionable, as it causes blackening of the pickles.

Salt.—There are two kinds of salt generally used, the refined salt and the ordinary. The former is used mostly in unfermented slow-process pickles and the latter in fermented and unfermented quick-process pickles. The refined salt is too expensive and, besides, the ordinary clean rock salt is satisfactory.

A saturated salt stock solution is prepared in a big barrel by dissolving salt in tap water until a reading of 90° to 100° salometer is obtained. This salt stock, after proper dilution, is used in brining the fruits or vegetables. The dilution depends upon the materials to be fermented; the more watery the raw material the more concentrated the brine should be.

Vinegar.—Clacial acetic acid of about 99 per cent purity is used, since it is colorless and free from sediment. This can be diluted to give any solution of the desired percentage of acetic acid.

Sugar.—In making sweet pickles, refined sugar is used. Brown sugar produces a cloudy pickle solution even after it has been strained through a cloth bag.

Spices.—The flavor, odor, and appetizing taste of many kinds of pickles are due largely to the species added to the brine or vinegar; but spices should be used in moderation and should not completely conceal the flavor of the fruit or vegetable.

The spices most commonly used are whole cloves, coriander, black pepper, bay leaves, cinnamon, celery seed, turmeric, and mace. These may be purchased in bulk and may be mixed as desired. In this work, whole spices bought from local grocery stores were used.

Coloring and hardening agents.—It is the practice in some households to "green" pickles by heating them with vinegar in a copper vessel. In this treatment there is formed copper acetate, which is a poisonous substance. Foods "greened" with copper salts, all of which are poisonous, are regarded as adulterated and cannot be sold. The use of green leaves such as grape and sugar cane to improve the color of the pickles is of doubtful value.

Alum is often used for the purpose of making pickles firm. However, if proper methods are followed in pickling, the salt and lactic acid in the brine will produce the desired firmness

of the pickle product. Although alum will make pickles crisp, its use is objectionable.

PICKLE SOLUTIONS

Sour solution.—The sour pickle solution is made by diluting the glacial acetic acid to the desired acidity. Usually 3 to 4 per cent acidity is used.

Sweet solution.—Two kinds of sweet pickle solution were used and made up as follows:

1. To 1 liter of 3.5 per cent acetic acid were added sufficient refined sugar (about 200 grams) to read 20° Brix, and 1 tablespoon of whole spices.

2. To 1 liter of 4 per cent acetic acid were added 1 tablespoon of whole spices and sufficient refined sugar (about 500 grams) to read 50° Brix.

The spices were placed in a piece of cheesecloth and then suspended in the solution, which was kept at 70° C. for ten minutes and then the heated solution, including the spices, was set aside overnight. The spiced sweet vinegar solution was strained before using.

The acidity and the amount of sugar to be added may be altered to suit individual taste.

EQUIPMENT

Scales.—A balance and set of weights were used in weighing the ingredients.

Measures for liquid.—For measuring liquids such as brine solution, vinegar, syrup, and water, a quart measure or a quart or pint jar, a gallon measure, and graduated cylinders were used.

For household use a quart measure is useful. If such a measure is not available, a graduated cylinder or a quart or a pint jar may be used instead.

Salt hydrometer, or salometer.—A salt hydrometer is used for measuring the approximate percentage of salt in the brine. This apparatus may be purchased for about 2 pesos from a drug store or a firm dealing in chemical apparatus. It is graduated into the so-called salometer degrees; 100° indicates a saturated salt solution, or 26.5 per cent salt; and 0° is taken from water only. Salometer degree divided by four gives the approximate percentage of salt. A 40° salometer reading is therefore equivalent to approximately a 10 per cent salt solution. The following table taken from Joslyn and Cruess (1929) shows the salt

percentages and the corresponding salometer readings and amounts of salt required for one gallon of water to prepare solutions of the desired salometer reading.

Per cent salt	Salometer degrees	Ounces salt per gallon	Per cent salt	Salometer degrees	Ounces salt per gallon	Per cent salt	Salometer degrees	Ounces salt per gallon
1	3.8	1.3	10	37.7	14.2	19	71.7	30.0
2	7.6	2.6	11	40.5	15.8	20	75.5	32.0
3	11.3	4.0	12	45.3	17.5	21	79.2	34.0
4	15.1	5.3	13	49.1	19.1	22	83.0	36.1
5	18.9	6.7	14	52.8	20.8	23	86.8	38.2
6	22.6	8.1	15	56.6	22.6	24	90.6	40.4
7	26.4	9.6	16	60.4	24.4	25	94.3	42.7
8	30.2	11.1	17	64.2	26.2	26	100.0	46.1
9	34.0	12.7	18	68.0	28.1	....	....	....

Cooking utensils.—In heating the pickles it is necessary to use aluminum, agate, or porcelain-lined kettles because of the chemical action of the acid in vinegar on most metallic vessels.

Containers.—For home use glass-top pint jars are satisfactory. The ordinary Mason jars provided with glass or porcelain covers are most desirable because zinc or other metallic caps are easily corroded by the vinegar and other acids in the brine. The zinc salts thus formed are poisonous. For commercial purposes different kinds of pickle bottles are generally used.

Siphon.—For determining the salt concentration or salometer reading of the brine solution of the fermenting vegetables or fruits it is necessary to transfer a part of the solution to a cylinder. To facilitate the transfer the device shown in fig. 1 was made.

Hand bottle capper.—A hand bottle capper was used. This capper cost 5 pesos.

EXPERIMENTAL

BLANCHING

Most vegetables are blanched before fermentation for the purpose of fixing and brightening their color. Generally, blanched vegetables of fruits improve in texture. Blanching is also done for cleansing purposes and for removing the objectionable odor or taste of some vegetables.

The vegetable or fruit is washed in tap water and then placed in a cheesecloth bag. The filled bag is immersed in boiling water, the time of immersion depending upon the texture of the material, but generally from two to five minutes is sufficient. After blanching, the vegetable or fruit is immediately placed in cold or cool running water.

FERMENTED FRUIT PICKLES

Freshly gathered, hard, firm, and mature fruits should be used. Small fruits may be used whole if desired. In most cases they are peeled, cut into halves, quarters, slices, or any desired shape. The peeled material is immediately dropped into a salt solution and allowed to ferment. The concentration of the brine solution varies from 40° salometer or 20 per cent salt, depending on the kind of fruits. Those fruits which are high in water content are fermented in stronger brine solution. During fermention the containers are kept full and the pickles well covered with brine at all times. To prevent the fruits from rising to the top of the brine, a screen made of bamboo (*asad*) is used. The stage of active fermenation continues for from one to three weeks. The quantity of lactic acid formed depends primarily upon the sugar content of the fruits being fermented, but it may be influenced by other factors such as temperature and strength of brine solution. The presence of acid is determined qualitatively by means of blue litmus paper and quantitatively by titration with a standard alkali solution. After fermentation is complete, as shown by the activity of the fermenting material, and more accurately by analysis, the fruit is ready to be made into either sweet or sour pickles.

The salt pickles prepared by this method are washed by being let stand in several changes of water until the excess salt is removed; or they may be placed in a vessel and set under tap water and a small stream allowed to flow into the vessel overnight. The pickled fruits are prepared like fruits for canning and are then packed into clean, dry jars. The jars are filled with the pickle solution and then processed in a water bath kept at 70° C., the length of time required for processing depending upon the kind of fruit.

For sour pickles, the fresh fruits are placed in a container and weak vinegar (2 per cent) is added. The volume should be sufficient to cover the fruit. They should be left in this vinegar for three to five days. After this treatment, the vinegar is raised to 3 per cent acidity or it may be replaced with a new 3 per cent vinegar solution. The fruits should be left in the vinegar for three to six days. The vinegar should finally be raised to 3.5 per cent acidity or stronger, if preferred. A few days in the last vinegar will complete the treatment of the pickles.

GUAVA

Some were cut into halves and the seeds removed, while the others were fermented whole. They were placed in separate containers, but an initial brine solution of 60° salometer was used in all cases. The fruits that were cut into halves reduced the brine solution to 45° salometer after four days, but the whole guavas reduced it to only 48°. The lactic acid formed was 0.46 per cent and 0.34 per cent, respectively. The fruits were made into sweet pickles. The texture and flavor of both were good.

HEVI

Four small barrels of hevi were prepared and fermented. In barrels 1 and 2 were fruits which were peeled and fermented whole. Barrels 3 and 4 contained peeled, sliced, and pitted hevi. All of them were started September 30, 1932.

To barrel 1 was added a brine solution of 50°. A week after, the reading dropped to 40°. After three weeks the reading was only 38°. Upon examination, the fruits were found to be soft. November 7 the reading was 38° and the fruits were still soft. November 10 salt was added so as to increase the concentration to 60° salometer. The reading dropped again to 57° November 14. The lactic acid was found to be 0.26 per cent. The fruits were so soft that they had to be discarded.

The fruits in barrel 2 had an initial brine solution of 60° salometer. From October 7 to the time the fruits were washed, November 14, the salometer reading varied from 57° to 59°. The lactic acid formed was 0.42 per cent. The seeds were removed from the fermented fruits, which were sliced and made into sweet pickles. The texture and flavor were good.

The contents of barrels 3 and 4 were also fermented in the same way as those of barrel 2.

PAPAYA

The fruits were peeled, pitted, and cut into small rectangles and other forms. November 18 the sliced fruits were placed in a barrel containing brine solution of 60° salometer. The next day the concentration was reduced to 40° and gradually dropped until, November 26, the hydrometer registered 37°. From that date there was a gradual decrease of concentration of salt until December 19 when the fruits were washed, the hydrometer reg-

istered 51°. The percentage of lactic acid formed was 0.082. The fermented fruits were tough, so they were cooked in steam until soft. They were used in the preparation of sweet and sour mixed pickles.

BALIMBING

After the edges were trimmed off the fruits were cut into segments and across the length, and placed in brine solution of 56° salometer for fermentation, which was started November 18. Readings were taken from time to time, and the brine concentration was maintained at not lower than 40° salometer. It may be noted from Table 1 that salt was added four times. From December 2 to December 19 the hydrometer readings varied from 43 to 45°. The fermented fruits were washed December 19 to remove the excess salt and then soaked in 4 per cent vinegar overnight. There was no discoloration, and the fruits were crisp and firm. The flavor was good. They were used in the preparation of sweet and sour mixed pickles.

FERMENTED VEGETABLE PICKLES

Vegetables are fermented in much the same way as fruits. Fermented vegetables owe their keeping quality mainly to lactic acid. Pickled products produced by fermentation are superior to all others in quality and appearance.

Vegetables properly prepared are placed in brine solution of from 40° to 80° salometer, depending upon their texture and water content. As soon as the vegetables are placed in the brine, osmotic action begins and continues until a state of equilibrium is established between the brine and the juices of the vegetables. This same action takes place in the case of fruits. Due to osmotic action the juice is drawn from the vegetables into the brine and the brine is taken up by the vegetables. At first the flow of juice outward is more rapid than the inflow of brine. This causes a slight shriveling of the vegetables. Later the inward flow is sufficiently rapid to cause the vegetable to become firm and plump again.

The juice that is drawn out of the vegetables contains, among other things, small amounts of sugar in solution. These sugars are used by the lactic acid. At the close of the fermentation period the vegetables are preserved in a mixture of brine and lactic acid.

Vegetables so treated are known as salt pickles or salt stock. They may be kept for a long period if properly protected or

they may be manufactured at once into the common types of edible pickles, such as sour and sweet pickles.

GREEN PEPPERS (SHORT VARIETY)

The materials were cut into halves and seeds removed. The materials thus prepared were washed with tap water and drained; then they were placed in a glass container and covered with a brine solution with an initial reading of 80° salometer. Up to November 7 the salometer reading remained almost constant. November 14, 1932, the salometer reading was 50° and the brine solution was neutral to litmus paper. The fermentation materials were washed and allowed to stand in water until the excess salt was removed. They were then soaked in a 4 per cent acetic acid solution overnight, and the next day the fermented peppers were packed and covered with a sweet pickle solution consisting of 3.5 per cent acetic acid plus sugar to read 44° Brix. There was a slight discoloration but the texture and flavor were good.

November 25, 1932, another batch of green peppers was used, but the initial reading of the brine was 60° instead of 80°. November 26, 1932, the salometer reading dropped to 44°. From that date to December 19 the brine solution was acidic to litmus paper. On titration the lactic acid was found to be 0.055 per cent. There was a slight discoloration. Texture and flavor were good. The fermented materials were used in the preparation of mixed pickles, both sour and sweet.

RED PEPPERS (LONG VARIETY)

December 12 red peppers were cut into halves and pitted and then immersed in brine solution of 54° salometer. The next day the reading dropped to 48°, and December 19 it was 43°. The lactic acid was found to be 0.0132 per cent. The peppers were washed, as usual, to remove the excess salt; then soaked in a 4 per cent acetic acid overnight, when they were ready for the preparation of mixed pickles. No fading of the red color was noticed. The texture was good, but the flavor was a bit too hot. Later experiments have shown that the biting taste can be removed by a longer period of fermentation.

AMPALAYA

Fresh green ampalaya was pitted and cut into rectangular pieces and across the length of the fruits, and then placed in a barrel containing brine of 60° salometer. After the first day,

September 27, the salometer reading was only 35°. September 28 the brine solution registered 48° salometer. From October 7 to November 14 the readings were almost constant, ranging from 52° to 53° salometer. Upon titration the lactic acid was computed to be 0.38 per cent. Like the rest they were washed, to remove the excess salt, and soaked in 4 per cent acetic acid overnight. The color of the fermented ampalaya was pale green. The texture and flavor were good. Some were put into vinegar of 44° Brix. Some were boiled in 4 per cent acetic acid in a copper container. The ampalaya assumed its original fresh color, but on account of the poisonous nature of the copper acetate this procedure is not to be recommended.

November 18 more apalaya was prepared and immersed in a brine solution of 56° salometer. November 19 the reading fell to 38°. It was claimed that below 40° salometer the vegetables were liable to spoil, so the brine concentration solution was increased to 48° November 26. November 27 the brine was again reduced to 36°, so some salt was added to increase it to 55° salometer. From November 28 to December 19 the readings were almost constant, ranging from 52° to 54° salometer. The lactic acid was found to be 0.026 per cent December 19. There was discoloration but the fermented vegetables were crisp and their flavor excellent. They were used in the preparation of sweet and sour mixed pickles.

BEANS

String beans.—The tips of the fresh materials were trimmed off and the beans cut in two lengthwise, washed, and immersed in a 40° brine solution. This was started September 26. September 27 the reading fell to 29° salometer. Salt was added to increase the reading to 58°. September 29 the reading was 49° salometer. From October 7 to November 14 the brine solution had a constant reading and a neutral reaction to litmus paper. After the excess salt had been removed, the beans were immersed in 4 per cent acetic acid, then packed and sweet pickle solution added. There was a slight discoloration, but the texture and flavor were good.

Green beans (habichuelas).—After the tips were cut off the beans were immersed in a brine solution having an initial reading of 40° salometer. The fermentation was started September 26. The next day the salometer reading was only 35°. In order to prevent the putrefaction of the material, the percentage of salt was increased to 12 per cent or a reading of 48°

salometer. September 28 there was a reduction of the salometer reading to 46°. From September 28 to the time the excess salt was removed on November 14, the reading ranged from 46° to 47° salometer. There was no lactic acid formed. A little discoloration resulted, but the texture and the flavor were good. They were made into sweet pickles.

Paayap.—The beans were prepared like the green beans, but a mat of grape leaves about an inch thick was placed at the bottom of a glass container before the beans were put in. Another layer of grape leaves was placed on top of the beans before a brine solution of 56° salometer was poured over the whole material. Fermentation was started November 18. November 26 the brine concentration was reduced to 33°. Salt was added to increase the reading to 43°. November 28 the reading was 45° salometer. There was an increase of 2° but the concentration was still lower than that of the initial brine solution. From that date of December 19 the different readings were almost constant, ranging from 44° to 45° salometer. December 19 the lactic acid was determined and found to be 0.059 per cent. The color faded a little, the texture was tough, and the flavor was poor. The beans were then cooked in steam until they softened somewhat. The texture was improved. The fermented materials were used in the preparation of sweet and sour mixed pickles.

Canadian Wonder Beans from Baguio.—These were prepared like the rest of the beans but fermented as whole beans. For the coloring agent sugar-cane leaves were used. The initial salometer reading of the brine solution used was 60°. November 28, or after two days' fermentation, the brine solution was 30° salometer. Salt was added to increase the salometer reading to 51°. From December 2 to December 19 the readings were constant. It may be seen from Table 1 that the lactic acid formed was 0.076 per cent. There was little fading in color. The texture and flavor were both good. The beans were used in the preparation of sweet and sour mixed pickles.

Some of the Canadian Wonder beans were blanched and fermented in brine solution having an initial reading of 52° salometer. This was started November 26, which was the same date as for the rest of the Canadian Wonder beans. November 28 the reading was 36°. The brine concentration was increased to 46°. From that date the salometer readings were constant, ranging from 45° to 46°. The lactic acid found was 0.064 per cent. There was also a discoloration, but the color of the beans

in general was better than that of the Canadian Wonder beans with which sugar-cane leaves were used as a coloring agent. The texture and flavor were good.

RADISHES

The radishes were peeled, quartered, washed, and placed in brine solution with an initial reading of 60° salometer. The fermentation was started September 26. The next day the reading dropped to 29°, and September 28 it rose to 50°, without extra salt being added. From October 7 to November 14 the reading varied from 51° to 53° salometer. The lactic acid was found to be 0.31 per cent. The excess salt was removed as usual, and the fermented material soaked in 4 per cent acetic acid overnight. The color was white and translucent. The radishes were very crisp in texture, and the flavor was excellent.

CUCUMBERS

The cucumbers were seeded, peeled, and cut into various sizes and forms. The fermentation was started November 18 with a brine solution of 56°. The next day, November 19, the reading suddenly dropped to 28°, so that salt had to be added to increase the brine concentration to 50° salometer. There was a gradual decrease of the percentage of salt until November 26, when the hydrometer registered only 25°. Again salt was added to increase the concentration to 49° salometer. November 28 the reading was 45° and was constant up to December 8; then rose to 47° by December 19. The lactic acid formed was 0.021 per cent. The fermented material was used in the preparation of sweet mixed pickles. The color was white and translucent. The cucumbers were crisp and their flavor was excellent.

SEGUIDILLAS

The seguidillas were cut in two. Some were treated with grape leaves and the rest with sugar-cane leaves. Both had an initial brine concentration of 60° salometer. Those with grape leaves decreased in the salt concentration gradually to 48° until they were washed, while those with sugar-cane leaves maintained their initial reading for more than a week. The fermentation of the seguidillas with sugar-cane leaves was so slow that the brine solution concentration was reduced only to 44° December 8. December 19, when the seguidillas was prepared for packing, the reading was 46° and the lactic acid 0.029 per cent. The seguidillas treated with grape leaves were darker in color than

those treated with sugar-cane leaves. Both were crisp in texture and of good flavor.

ONIONS (WHITE AND PURPLE VARIETIES)

After the outer skin was removed the onions were soaked in water for three days, the water being occasionally changed. They were then placed in brine solution with an initial concentration of 61° December 16. December 17 the reading dropped to 31° and was increased to 51° by adding salt. December 19 it dropped again and registered 49° on the hydrometer. The onions assumed a darkened color, but after immersion in 4 per cent acetic acid, the original color was restored. The onions were used in the preparation of sweet and sour mixed pickles.

MIXED PICKLES

In the preparation of mixed pickles, various combinations of vegetables are used, depending upon the mixture desired. In the United States and in Europe, onions, cauliflowers, green and red peppers, tomatoes, beans, and cucumbers are generally used.

QUICK-PROCESS FERMENTED PICKLES

Generally the materials are washed thoroughly and prepared like those for fermented pickles. The vegetables or fruits are then placed in the container and covered with brine of from 40° to 60° salometer. The materials are left in the brine solution for twenty-four hours. After brining, the vegetables or fruits are washed, to remove the excess salt, and then soaked in 4 per cent vinegar. These vegetables may be made into either sour or sweet pickles.

CUCUMBERS

Fresh materials were used. They were seeded, peeled, and sliced crosswise (about 0.25 inch thick), and the thin slices were immersed for five days in brine solution of 56° salometer. The final reading of the brine solution was 40° salometer. The excess salt was removed by allowing the pickles to stand in tap water for a few hours. A sweet pickle solution of 3.5 per cent acetic acid and 50° Brix heated with allspice at 70° C. was used. The finished products were processed for ten minutes at 70° C. The texture was crisp and the flavor good.

Another lot of large cucumbers was prepared November 25, 1932. The fresh materials were peeled as usual and cut into small rectangles. The initial brine concentration was 40° salo-

meter, or approximately 10 per cent salt. The next day the hydrometer reading fell to 25°. After the excess salt was removed they were packed and a pickle solution of 4 per cent acetic acid with sugar to make it 20° Brix was added. The finished product was processed for ten minutes at 70° C. The texture and the flavor were good.

EGGPLANTS

November 18 some eggplants were prepared like those for the fermented pickles. The cut eggplants were immersed for four days in an initial brine solution of 56° salometer. On the fourth day the salt concentration was found to be only 41°. The color faded. The eggplants were made into sweet pickles. Even after the processing for fifteen minutes the skin was tough. The flavor was fairly good.

SEGUIDILLAS

These vegetables were cut uniformly and blanched in boiling water for two minutes. They were then placed in a brine solution of 40° salometer overnight. There was a little discoloration of the material. After the excess salt had been removed, they were made into sweet pickles. The finished product was crisp and the flavor was good.

SLOW PROCESS UNFERMENTED PICKLES

The vegetables were washed and prepared ready for packing. They were placed in containers and the proper pickle solution added, care being taken to cover the vegetables completely. After two or three weeks they were ready for packing.

CUCUMBERS

Cucumbers of medium size were peeled and cut into thin sections crosswise. The seeds were removed and the slices covered with a solution consisting of 4 per cent acetic acid, plus refined sugar to make 20° Brix, with 1 cup refined salt per gallon. The acidity was titrated from time to time and was maintained at about 4 per cent. December 7, or after a period of twelve days, they were finally packed and processed for five minutes. The cucumbers turned soft, but the flavor was fairly good.

RADISHES

The fresh raw materials were washed and peeled and cut into quarters. A solution exactly the same as that used for the cucumbers was also used. The acidity was titrated from time to time, keeping it around 4 per cent. After a period of twelve

days they were bottled and processed for five minutes. The finished product was good both in flavor and texture.

PACKING AND PROCESSING

The appearance of the finished product depends largely upon the manner in which it is packed in the bottles. The various kinds of vegetables and fruits should be arranged in as neat and attractive a manner as possible. Bottles should not be filled entirely.

According to Chenoweth (1930), the processing is the most important operation in canning. No matter how carefully all other steps have been performed, if the processing is not thorough trouble is sure to result. Great skill is required to be able to process food sufficiently long to insure its keeping and at the same time to secure the maximum quality.

When glass-topped jars are used, place them in a water bath so that the water and the pickle solution are at the same level. Heat the water in the bath to from 70° to 80° C. for five to ten minutes, depending upon the material to be pasteurized. At the end of this period remove the containers from the bath and close the jars tightly. Invert the jars and allow them to cool in this position overnight.

If pickle bottles are used they are loosely corked and pasteurized by a similar method. At the end of the heating period, the bottles are removed from the bath and the corks seated tightly by the corking device. To prevent the entrance of air the corks should be sealed with a lacquer such as can be bought from stores dealing in paints and varnishes.

DISCUSSION OF RESULTS

The results of fermented and unfermented pickle experiments are recorded in Tables 1 and 2, respectively.

FERMENTED FRUIT PICKLES

All the fruits that were fermented proved to have good pickling qualities. A brine concentration of from 40° to 60° salometer was found satisfactory for fermenting guavas. It may be noted from Table 1 that by using such concentrations, lactic acid of 0.46 and 0.34 per cent was formed. The texture of the fruit after fermentation was fairly good.

Below 40° salometer, or approximately 10 per cent salt, hevi softens readily. It was found that after the fruits have softened the addition of more salt to increase the brine concentration

will not prevent further softening. Like guavas, hevi can be fermented in a brine solution of 50° to 60° salometer. The resulting pickled product was of a very good texture.

The native way of preparing papaya pickle is to grate the fruits or vegetables, blanch them in boiling water, and cover them with sweetened vinegar. In the present work it may be noted in Table 1 that papayas can be safely fermented in a brine solution of 50° salometer. Even at 40° salometer, or approximately 10 per cent salt, the sliced fruit did not soften.

Balimbing was fermented in a brine solution having an initial reading of 56° salometer. Due to the water content of the fruit the original brine concentration was diluted to 38° salometer. Table 1 shows that salt was added four times before the reading became constant at around 44° and 45° salometer. The reading was always fixed above 40° salometer because experimenters have found that most fruits and vegetables putrefy in brine solutions below such concentration. After a period of about one month, a final reading of 43° salometer was obtained, 0.098 per cent lactic acid was formed, and the fruits became firm and crisp.

FERMENTED VEGETABLE PICKLES; PEPPERS

As a result of the various trials it may be stated that peppers in general can be safely fermented in a brine solution having a concentration of from 45° to 50° salometer. It was found that at 70° salometer and above, fermentation was checked. This may be due to the fact that in such brine concentrations the lactic acid bacteria cannot thrive. The biting taste of peppers can be lessened by washing them well in several changes of tap water before fermenting, and also by proper curing.

AMPALAYA

Some ampalaya was prepared and fermented September 26 with an initial brine concentration of 60° salometer. On the next day so much of the salt had been absorbed by the vegetables that the salt solution was decreased to 35° salometer. No salt was added and on the second day, September 28, the reading was found to be 48°. The increase may have been due to the fact that some of the salt had been given off by the vegetables with the vegetable juice. From October 7 to November 14 the readings were around 52° and 53° salometer. The lactic acid formed was 0.38 per cent, and the pickled products had a good texture.

November 18 another trial was made. The brine solution used for fermentation had an initial brine concentration of 56° salom-

eter. The reading was kept around 53° and 54° for aperiod of one month, and the resulting product was good.

From these results it can be stated that ampalayas can be safely fermented in a salt solution of from 50° to 60° salometer.

BEANS

According to the results of fermenting various beans—such as, string beans, habichuelas, paayap, and Canadian Wonder beans from Baguio—it has been found that they need a lower concentration of salt solution. About 40° to 45° salometer is enough for fermentation. The use of grape leaves and sugar-cane leaves to preserve the green color is still of doubtful value. However, grape leaves are better than sugar-cane leaves. Blanching and proper long-time curing seems to be more effective in preserving the green color of the beans.

RADISHES

With these vegetables a brine solution of from 50° to 55° salometer is just right for fermentation without softening the texture. If the radishes are cured in salt solution of that range of concentration for from three to four weeks, a translucent white pickle will be produced.

CUCUMBERS

In most references cited in this paper, most of the authors used a salt solution of 60° salometer for fermenting cucumbers, but in these experiments it was found that a concentration of from 45° to 50° salometer was also safe to use.

SEGUIDILLAS

The range of brine concentration for fermenting varies from 45° to 50° salometer. There is not much lowering of the reading after the first day of immersion in the brine solution, so that if the initial reading is 50° salometer, the addition of salt on the second day is no longer necessary. Grape leaves were found to be more effective than sugar-cane leaves for the preservation of the green color. With the use of grape leaves a darker green color was produced.

ONIONS

Before fermentation it was necessary to soak the onions in fresh water, changing the water daily for two or three days. It was found that onions not soaked in water and fermented turned dark and the original color did not return even after soaking in a 3 or 4 per cent vinegar; while those that were soaked in water

before fermentation returned to their natural color after immersion in vinegar. The brine concentration safe enough for the fermentation of onions is from 50° to 60° salometer.

SUMMARY AND CONCLUSIONS

1. In general the fermented pickles were better in texture and flavor and keeping qualities than the unfermented pickles. The fermented pickles possess a characteristic, pleasing flavor due to the presence of lactic acid in the tissue of the fruit or vegetable.

2. Below 40° salometer hevi softened in texture and after softening the addition of more salt to raise the brine concentration of over 40° failed to prevent further softening of the fermented material.

3. On account of the toughness of the resulting fermented materials, eggplants, paayap, and papaya should be steamed before bottling.

4. Most of the native fruits and vegetables—namely, ampalaya, radishes, cucumbers, papaya, onions, beans, seguidillas, balimbing, cauliflower, chayote, etc.—have good pickling qualities.

5. In general most fruits and vegetables should be fermented in brine solutions of from 45° to 60°, or approximately 11 to 15 per cent salt solution.

6. The ordinary granular table salt has been found satisfactory for pickling fruits and vegetables. Better quality salt is, of course, more desirable for pickling.

7. Our studies on pickling by fermentation show that there is a bright prospect for the establishment of fermenting stations on Philippine farms to utilize surplus production of fruits and vegetables.

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TABLE 1.—*Observations on the pickling qualities of some Philippine fruits and vegetables in the preparation of fermented pickles*

Fruit or vegetable	Date of observation	Brine solution	Acetic acid	Composition of pickle solution: Sugar	Composition of pickle solution: Acetic acid	Processing at 70° C.	Observation after fermentation: Color	Observation after fermentation: Texture	Observation after fermentation: Flavor
	1932	[a] *Sal*	*P. ct.*	[a] *Brex*	*P. ct.*	*Min*			
Ampalaya (sliced in big pieces)	Sept. 26	80	Neutral to litmus.	44	3.5	20	Light green	Good	Good.
	Sept. 27	47							
	Sept. 28	47							
	Oct. 7	48							
	Oct. 14	49							
	Oct. 21	49							
	Oct. 28	48							
	Nov. 7	49							
	Nov. 14	50							
Balimbing (segmented)	Nov. 18	56	0.098	50	4.0	10	No discoloration.	Crisp	Do.
	Nov. 19	39							
	Nov. 17	42							
	Nov. 22	38							
	Nov. 22	47							
	Nov. 26	38							
	Nov. 26	53							
	Nov. 28	40							
	Nov. 28	47							
	Dec. 2	45							
	Dec. 5	44							
	Dec. 8	44							
	Dec. 14	44							
	Dec. 19	43							
Beans, string	Sept. 26	40	Neutral to litmus.	44	3.5	20	Yellowish green.	Good	Do.
	Sept. 27	29							
	Sept. 27	58							
	Sept. 28	49							
	Oct. 7	50							
	Oct. 14	52							
	Oct. 21	54							
	Oct. 28	53							
	Nov. 7	53							
	Nov. 14	53							

[a] Increased.

TABLE 1.—*Observations on the pickling qualities of some Philippine fruits and vegetables in the preparation of fermented pickles*—Continued

Fruit or vegetable	Date of observation	Brine solution	Acetic acid	Composition of pickle solution		Processing at 70° C.	Observation after fermentation		
				Sugar	Acetic acid		Color	Texture	Flavor
	1932	a *Sal*	*P. ct.*	a *Brex*	*P. ct.*	*Min.*			
Beans, Baguio (green)	Sept. 26	40	Neutral to litmus.	44	3.5	20	Light green	Good	Good.
	Sept. 27	35							
	Sept. 27	48							
	Sept. 28	46							
	Oct. 7	46							
	Oct. 14	52							
	Oct. 21	47							
	Oct. 28	46							
	Nov. 7	47							
	Nov. 14	47							
Beans, Canadian Wonder (plus sugar-cane leaves)	Nov. 26	60	0.076	50	4.0	10	Little fading	do	Do.
	Nov. 28	30							
	Nov. 28	51							
	Dec. 2	55							
	Dec. 8	55							
	Dec. 14	53							
	Dec. 19	53							
Beans, Canadian Wonder (blanched)	Nov. 26	52							
	Nov. 28	36							
	Nov. 28	46							
	Dec. 2	46							
	Dec. 8	46							
	Dec. 14	45							
	Dec. 13	45							
Cucumber (peeled and cut into rectangular form)	Nov. 18	56	0.021	50	4.0	10	White, translucent.	Crisp	Excellent.
	Nov. 19	28							
	Nov. 19	50							
	Nov. 22	40							
	Nov. 26	25							
	Nov. 26	49							
	Nov. 28	45							
	Dec. 2	45							
	Dec. 8	45							
	Dec. 14	45							
	Dec. 19	47							

Eggplant (halved and quartered. Plus grape leaves.)	Nov. 18	56	0.029	50	4.0	10	Faded	Tough skin	Fair.
	Nov. 19	38							
	Nov. 19	48							
	Nov. 22	46							
	Nov. 26	36							
	Nov. 26	55							
	Nov. 28	54							
	Dec. 2	54							
	Dec. 5	54							
	Dec. 12	52							
	Dec. 19	53							
Eggplant (halved and quartered)	Nov. 25	40	0.042	50	4.0	10	do	do	Poor.
	Nov. 26	28							
	Nov. 26	45							
	Nov. 28	36							
	Nov. 28	46							
	Dec. 2	45							
	Dec. 8	44							
	Dec. 14	44							
	Dec. 19	48							
Guava (halved)	Oct. 10	60	0.46	44	3.5	22	Light brown	Fairly good	Good.
	Oct. 14	45							
	Oct. 21	46							
	Oct. 28	45							
	Nov. 7	45							
	Nov. 14	45							
Guava (whole)	Oct. 10	60	0.34	44	3.5	20	do	do	Do.
	Oct. 14	48							
	Oct. 21	48							
	Oct. 28	48							
	Nov. 7	46							
	Nov. 14	46							
Hevi (peeled, whole)	Sept. 30	50	0.26	(b)	(b)		do	Soft	
	Oct. 7	40							
	Oct. 21	39							
	Oct. 28	38							
	Nov. 1	38							
	Nov. 7	38							
	Nov. 10	60							
	Nov. 10	(a)							
	Nov. 14	57							

[a] Increased.

[b] Not packed.

TABLE 1.—*Observations on the pickling qualities of some Philippine fruits and vegetables in the preparation of fermented pickles*—Continued

Fruit or vegetable	Date of observation	Brine solution	Acetic acid	Composition of pickle solution		Processing at 70° C.	Observation after fermentation		
				Sugar	Acetic acid		Color	Texture	Flavor
	1932	[a] *Sal*	*P. ct.*	[a] *Brex*	*P. ct.*	*Min.*			
Hevi (peeled whole)	Sept. 30	50	0.42	44	3.5	20	Light brown	Fairly good	Good.
	Oct. 7	58							
	Oct. 14	59							
	Oct. 21	59							
	Oct. 28	57							
	Nov. 7	58							
	Nov. 14	58							
Hevi (peeled and sliced)	Sept. 30	50	0.49	44	3.5	20	do	Good	Do.
	Oct. 7	48							
	Oct. 14	48							
	Oct. 21	49							
	Oct. 28	50							
	Nov. 7	51							
	Nov. 14	51							
Hevi (peeled and sliced)	Sept. 30	60	0.49	44	3.5	20	do	do	Do.
	Oct. 7	50							
	Oct. 14	49							
	Oct. 21	49							
	Oct. 23	50							
	Nov. 7	50							
	Nov. 14	50							
Onion (Tagalog) (soaked in water for three days)	Dec. 16	61	....	50	4.0	10	Dark	do	Do.
	Dec. 17	31							
	Dec. 17	51							
	Dec. 19	49							
Paayap (plus grape leaves)	Nov. 18	56	0.059	50	4.0	10	Little discoloration.	Tough	Poor.
	Nov. 19	41							
	Nov. 26	33							
	Nov. 21	43							
	Nov. 28	45							
	Dec. 2	45							
	Dec. 10	44							
	Dec. 17	44							
	Dec. 19	44							

Papaya (peeled and cut into rectangular pieces)	Nov. 18	60	0.082	50	4.0	10	White, not translucent.	Tough	Good.
	Nov. 19	40							
	Nov. 22	41							
	Nov. 26	37							
	Nov. 26	57							
	Nov. 28	56							
	Nov. 29	55							
	Dec. 2	55							
	Dec. 5	54							
	Dec. 12	53							
	Dec. 19	51							
Pepper (green, halved)	Nov. 25	60	0.055	50	4.0	10	Faded	do	Do.
	Nov. 26	44							
	Nov. 28	44							
	Dec. 2	45							
	Dec. 10	45							
	Dec. 17	44							
	Dec. 19	44							
Pepper (red, halved and seeds removed)	Dec. 12	54	0.132	50	4.0	10	Red	do	
	Dec. 13	48							
	Dec. 14	52							
	Dec. 17	44							
	Dec. 19	43							
Pepper (green, halved)	Sept. 26	80	Neutral to litmus.	44	3.5	20	Light green	do	Do.
	Sept. 27	47							
	Sept. 28	47							
	Oct. 7	48							
	Oct. 14	49							
	Oct. 21	49							
	Oct. 28	48							
	Nov. 7	49							
	Nov. 14	50							
Radish (peeled and quartered)	Sept. 26	60	0.31	44	3.5	20	White translucent.	Crisp fine	Excellent.
	Sept. 27	29							
	Sept. 28	50							
	Oct. 7	52							
	Oct. 14	53							
	Oct. 21	53							
	Oct. 28	51							
	Nov. 7	51							
	Nov 14	52							

[a] Increased.

TABLE 1.—*Observations on the pickling qualities of some Philippine fruits and vegetables in the preparation of fermented pickles*—Continued

Fruit or vegetable	Date of observation	Brine solution	Acetic acid	Composition of pickle solution		Processing at 70° C.	Observation after fermentation		
				Sugar	Acetic acid		Color	Texture	Flavor
	1932	[a] *Sal*	*P. ct.*	[a] *Brix*	*P. ct.*	*Min.*			
Radish (peeled and quartered)	Nov. 25	64	0.076	50	4.0	10	White	Crisp	Good.
	Nov. 26	33							
	Nov. 26	60							
	Nov. 28	48							
	Dec. 2	51							
	Dec. 10	51							
	Dec. 17	48							
	Dec. 19	48							
Seguidillas (plus grape leaves)	Nov. 22	60	0.078	50	4.0	10	Dark	do	Fair.
	Nov. 23	54							
	Nov. 26	47							
	Dec. 2	49							
	Dec. 10	48							
	Dec. 17	48							
	Dec. 19	48							
Seguidillas (plus grape leaves)	Nov. 25	60	0.029	50	4.0	10	Little discoloration.	do	Do.
	Nov. 28	60							
	Dec. 2	60							
	Dec. 8	60							
	Dec. 8	44							
	Dec. 10	45							
	Dec. 14	45							
	Dec. 19	46							

[a] Increased.

TABLE 2.—*Showing results with unfermented pickles*

Kind of vegetable	Quick process							
	Date of observations	Brine solution	Composition of pickles solution		Processing at 70° C.	Observations		
			Sugar	Aceitic acid		Color	Texture	Flavor
	1932	° *Sol*	° *Brix*	*P. ct.*	*Min.*			
Cucumber	Nov. 18	56						
Do.	Nov. 23	40	50	3.5	10	White	Crisp	Good.
Eggplant	Nov. 18	56						
Do.	Nov. 22	41	44	3.5	15	Faded	Tough	Fair.
Cucumber	Nov. 25	40						
Do.	Nov. 26	25	20	4.0	15	White	Good	Good.
Seguidillas (blanched)	Nov. 25	40						
Do.	Nov. 26	37	50	3.6	10	Light green	Crisp	Do.

Kind of vegetable	Slow process							
	Date of observation	Composition of pickles solution			Processing at 70° C.	Observations		
		Sugar	Aceitic acid	Salt		Color	Texture	Flavor
	1932	° *Brix*	*P. ct.*		*Min.*			
Cucumber	Nov. 25	20	4	1 cup gallon				
Do.	Dec. 7	(a)	(a)	(a)	5	White transparent	Soft	Fairly good.
Radish	Nov. 25	20	4	1 cup gallon				
Do.	Dec. 7	(a)	(a)	(a)	5	White	Good	Good.

ILLUSTRATIONS

PLATE I

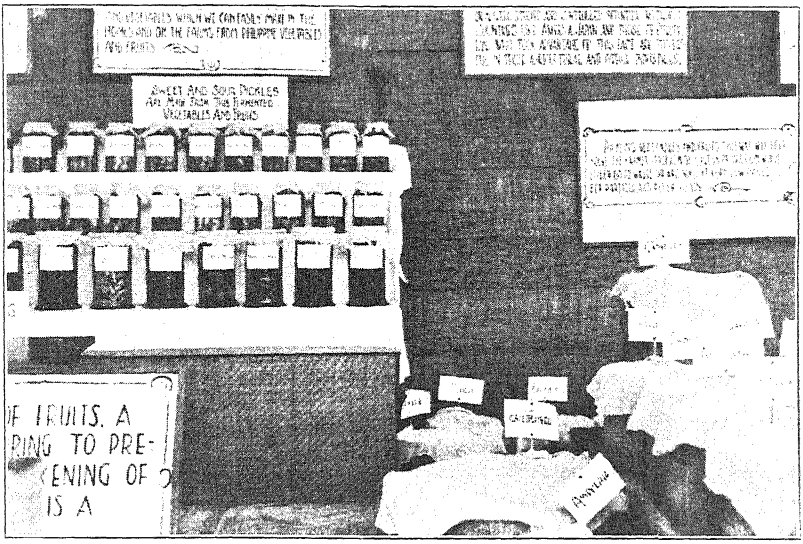
Fermentation of Philippine fruits and vegetables in barrels. A device for siphoning off the liquid and a salometer spindle are shown.

PLATE II

(*a*) Showing the fermented fruits and vegetables in process of preservation.

(*b*) Showing the finished products and spices and condiments used in their preparation.

PLATE I.—Fermentation of Philippine fruits and vegetables in barrels. A device for siphoning off the liquid and a salometer spindle are shown.



(*a*) Showing the fermented fruits and vegetables in process of preservation.

(*b*) Showing the finished products and spices and condiments used in their preparation.

PLATE II.

STUDIES ON THE QUICK FREEZING OF PHILIPPINE FRUITS AND THE UTILIZATION OF THE FROZEN PACK PRODUCTS

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NINE PLATES

Present methods of fruit preservation may be grouped into two general classes, the first of which includes all those methods which give permanent preservation whereby the microörganisms capable of causing spoilage are killed by heat and the entrance of others prevented by the use of hermetically sealed containers, while the second takes in those methods in which conditions are made unfavorable to the growth and activity of microörganisms. Freezing and refrigeration storage belong to the second class. They give temporary but not permanent preservation.

The spoilage of food products is due to the action of certain enzymes, molds, yeast, and certain types of bacteria. The fruits and vegetables undergo biological changes which result in ripening, respiration, and other normal life processes. The microörganisms and enzymes which may work on the fruits and vegetables, as well as the ripening, respiration, and other normal processes of the fruits are most effective at certain optimum temperatures. As the temperature is lowered the enzyme action and the growth and multiplication of microörganisms are retarded, and when the drop in temperature reaches a certain limit, these activities may be entirely inhibited.

For the equable distribution of perishable foodstuffs, such as fruits, vegetables, and other food products, and for the transportation of such products to distant places, freezing storage has been practiced for more than twenty years. Apples and

other temperate fruits have been successfully kept in freezing storage for more than a year.

The refrigeration and freezing storage of temperate fruits has been the subject of numerous investigations. The extensive researches of Cruess, Diehl, Sckart, Chace, Fellers, Poore, Marsh, Birdseye, Joslyn, Overholser, Bjarnason, Taylor, Wiegand, Woodruff, and many others form the basis of present commercial practices of freezing and refrigeration storage of fruits, vegetables, meat products, fish, and other foodstuffs.

In the case of tropical fruits, however, very little work has been done along the line of preservation by freezing. In the Philippines, Higgins and Punzalan, in 1925, conducted some experiments on the refrigeration of mangoes for the purpose of determining the right temperature of storage so that these fruits might be shipped to nearby Oriental ports and possibly to America and Europe. They found that when mangoes are kept at 36°F. the fruits remained without injury for eighteen or more days but not over thirty-five days. In experiments conducted in this laboratory along the same line but using even lower temperatures and subjecting the mature but green mangoes to various treatments to delay maturity, we have found that this method of preservation for the purpose of commercial exportation is not satisfactory. After several unsuccessful attempts at delaying the maturity of mangoes, we have come to the conclusion that other methods of low-temperature treatment must be employed in order to be able to export mango and other Philippine fruits to foreign countries.

In going over the literature on freezing and refrigeration storage, we find that a good deal of work has been done on the subject in the United States by the investigators just mentioned. Therefore, it was thought that the successful results obtained by American investigators might be obtained in the freezing preservation of Philippine fruits.

When fruits are subjected to temperatures of at least 10 to 15° F., molding, fermentation, bacterial action, and the normal ripening and respiration processes are mostly, if not entirely, inhibited. The researches of Diehl have shown that by reducing the temperature of the fruits to — 40°F. as quickly as possible the growth and multiplication of spoilage organisms are temporarily retarded and the fermentation and spoilage thereby prevented. However, the darkening of the tissues, deterioration

in color, and development of an unnatural flavor will be apparent as these changes are known to occur even at the freezing temperatures owing to oxidation of certain constituents of the fruit. Oxidation has been found to be due to a large extent to the action of the enzyme oxidase, which is present in the fruit tissues and is not inhibited even at 0° F.

Researches on the freezing of plant tissues indicate that during freezing, ice forms in the tissues, generally not in the cells but in the intercellular spaces, the water moving out of the cells to form ice crystals in the spaces. As the freezing continues, the intercellular spaces between the ice and the plant tissues is filled. Injury to the texture is apparently due to the disrupture of the cell tissues and most likely to changes in the colloidal nature of the cell contents. Freezing is known to affect markedly the properties of gels and the loss in turgidity of fruit after ordinary freezing may be due to this phenomenon. The separation of water in the form of ice in and between the cells that is not absorbed produces a soft, limp, and soggy texture of the frozen fruit when it thaws.

If the temperature is very low, from –10° to –50° F., rapid freezing takes place and the entire fruit tissue freezes, resulting in the crystallization within as well as between the cells. All other conditions considered, the lower the temperature the smaller the ice crystals distributed throughout the tissues. Fruits and other food products like vegetables, meat, fish, etc., when rapidly frozen were found to be better preserved in color flavor, and texture.

It was, therefore, the object of this study to make experiments in the slow and quick freezing of some Philippine fruits which give promise of being commercially valuable for export and to determine the best methods of utilizing the frozen-pack fruits.

MATERIALS

The following Philippine and Philippine grown fruits were used in the experiments: strawberries, mangoes, avocados, lanzones, ates, guavas, young coconuts, pineapples, nangkas, lemasas, chicos, and zapotes.

Practically all these fruits were grown and harvested in the Plant Propagation Stations of the Bureau of Plant Industry. Some of them were picked when they were still green but already mature and then immediately shipped to the laboratory, where

they were allowed to ripen. As a rule fully ripe and sound fruits were used in the experiments.

Syrup.—First-class refined sugar was used in preparing syrup of different concentrations. The right amount was dissolved in water and the concentration of the syrup tested by means of a Brix hydrometer. The prepared syrup was then filtered through a double layer of muslin and then precooled in an ice box before using. Sugar solutions of from 20° to 70° Brix were prepared and used in the experiments. It was found that when fruits were frozen without syrup or by the addition of powdered refined sugar, there was much shrinkage in volume, and surface discoloration of the frozen fruits was quite apparent.

Joslyn found several advantages in the use of syrup for frozen pack fruits. Some of these are—

1. Discoloration is reduced to a minimum due to the exclusion of air from the surface of the fruit.
2. For more uniform distribution throughout the mass of the fruit syrup is more convenient to use than powdered sugar.
3. The addition of syrup rather than powdered sugar entails less damage to the fruit.
4. A more uniform and attractive pack is obtained because of less shrinkage in volume and no setting of the fruit in the container as occurs in the powdered pack.
5. Syrup can be chilled before use and therefore is a better aid to preservation.
6. The texture of the thawed fruit is better.
7. The syrup pack is applicable to all fruits.

Containers.—The following containers can be used:

No. 2 sanitary cans.
1-pint and ½-pint cartons obtained from New York.
Gallon-size slip cover tin can obtained locally.

For family use, the small size containers are satisfactory. The larger containers are better suited for export and for restaurant and hotel use.

Convenient-sized wooden boxes of barrels lined with paraffin would be good for the export trade.

IV. *Freezers and storage chambers.*—The syrup and powdered packed fruits were frozen in three ways, namely:

At 18° F., using the cold-storage chamber of the Government Ice Plant.
At 0° F., using the freezing chamber of a commercial local company.
At -20° to -40° C., using a rapid freezer, loaned by a local company.

After the fruits were frozen, they were removed to storage chambers and stored at 0°, 8°, and 18° F.

EXPERIMENTAL

STRAWBERRIES

Strawberries are shipped from our Baguio Station in specially constructed, well-ventilated shipping boxes. Using these boxes, there is less spoilage than by the former method of transporting the berries in bamboo baskets. The berries arrive in our laboratory the next day after picking. About 90 per cent of them are utilized for the frozen pack and the rest for jam and other food preparations. The strawberries are carefully sorted, stemmed and washed to remove all foreign materials and impurities. Only fully ripe, sound berries, free from decay and bruises and not too soft, are utilized for the freezing experiments, and the discarded berries are made into jams, jellies, and wine. After being washed, the berries are drained and then packed into paraffined cartons or standard sanitary No. 2 cans. As soon as the containers are filed with strawberries, a previously prepared and precooled syrup of 50 to 60 per cent is added to completely cover the fruit. Some are packed with plain sugar in the proportions of 1:1, 1:2, 1:2.5, and 1:3 in the same type of containers. This is done by adding the fruit and the sugar in alternate layers in order to obtain a uniform mixture of fruit and sugar. In the case of the cartons, the lid is put on and with the cans they are sealed by a hand-sealing machine. Then they are sent to cold storage, and frozen and stored at 18° F. the lowest available temperature at the start of our experiments. Later, however, we were able to freeze our products at 0° F. and —40° F. through the courtesy of a local firm.

MANGOES

Fully ripe mangoes free from blemishes, bruises, and decay are washed in cold water; peeled with a stainless knife and halved, quartered, and sliced. The edges are trimmed to prevent as far as possible, disintegration of the fibers. Another method of preparation is to open the fruit without peeling it and then scoop the flesh from the halved fruit with a silver spoon. Two roundish portions are removed from a half, or four from a whole fruit. Still another way is to pack it in the crushed form, by passing the peeled, pitted, and halved fruit through a meat grinder.

The halved, quartered, sliced, or scooped-out pieces of mango are then packed into cartons, No. 2 sanitary cans, or slip-cover

gallon cans. A 40 to 50 per cent syrup is added to completely cover the entire fruit, the containers are properly closed and sealed and are then ready for freezing. To the crushed mangoes 50 per cent by weight dry sugar is added, or a 1:2 pack, filled into slip-cover gallon cans, and taken to cold storage.

Some were frozen at 18° F. and stored at the same to temperature, some at 0° F. and then after two days removed to the 18° F. room. The rest were frozen by means of solid carbon dioxide in a well-insulated quick-freezer the temperature of which ranged from —40 to —60° F. After quick freezing, which takes from three to five hours, depending on the size and type of the containers used and nature of the product, they are transferred to the 18° F. cold storage.

AVOCADOS

Well-matured, ripened avocados free from decay and bruises are peeled, pitted, and halved, quartered, or liced. Some are crushed by passing them through a meat grinder and packed with a 25 to 40 per cent dry sugar. The prepared fruits should be packed immediately, as delay in packing exposes them to oxidation and consequent discoloration. The halved, quartered or sliced fruits are packed into containers and covered with a 50 to 60 per cent syrup, and frozen at the different temperatures used for mangoes. Later, they are transferred to the 18° F. cold storage.

LANZONES

Fully ripe lanzones are washed in cold water, sorted, and opened. The segments are separated, and only seedless segments packed into containers. A syrup of 70 per cent is added to the fruit and frozen at —40° F. and stored at 18° F. Experiments on the freezing of the whole fruits without peeling them were tried by packing them in different strengths of syrup from 10 to 80 per cent.

ATES

In the case of ates, the ripe fruit is opened, the pulp scraped out with a spoon and packed direct into containers with the seeds. Another portion is packed after removing the seeds by passing the pulp through a small mesh bamboo sieve. The operator wears rubber gloves during the pulping operation. This precaution is used in other fruit preparations. Syrup ranging from 20 to 70 per cent was used, the containers are properly sealed and then the fruits are frozen.

GUAVAS

Fully ripe guavas are thoroughly washed, trimmed and halved. The seeds are scraped out with a spoon and only the pulp packed, with 70 per cent syrup. The fruits are frozen and stored at 18° F. Some were packed with seeds, all the fruit being simply cut into halves.

YOUNG COCONUTS

Young coconuts (buko) are opened, and the meat scraped out with a spoon or grated with a hand greater taking care not to include the red skin underneath. The prepared meat is packed with a 40 to 50 per cent syrup, and also with syrup made from coconut water. Freezing temperature of 18° and 0° F. were used in freezing coconuts.

MISCELLANEOUS FRUITS

Pineapples are peeled, washed, cored and sliced, and packed into containers with 50 to 60 per cent syrup. Nangkas and lemasas are opened and the seeds removed from the pulp. All adhering filaments are also removed and only the good meat is packed into containers with 60 per cent syrup and frozen at 18° F.

Ripe nangkas and lemasas are opened, and the seeds separated from the segments and washed thoroughly in cold water to remove adhering gums and other sticky matter. The cleaned pulp is packed into containers and a 60 per cent syrup added to completely cover the fruits. Then they are sent to cold storage and frozen at 18° F.

Fully ripe but not soft chicos are peeled, quartered, cored, and the seeds removed. The fruits are packed into cans and cartons with 40 per cent syrup and frozen at 0° F.

Ripe zapotes are opened and the pulp passed through a 40-mesh sieve to separate the pulp from the fiber and seeds. The prepared pulp is packed into cans and cartons with sugar in different proportions; namely, 1:1, 2:1, 2.5:1, and 3:1, and frozen at 0° F. The 2:1 pack, which means 2 parts of pulp to 1 part of sugar, was found to be best in the preparation of ice cream and sherbet.

DISCUSSION OF RESULTS

STRAWBERRIES

Strawberries preserved by freezing retained the flavor, color, and texture of the fresh fruit. The desired flavor and sweetness which is lacking in the fresh fruit is obtained by the addition

of sugar. Strawberries packed with dry sugar in the proportion 1:1 and 2:1 showed much shrinkage, and in color the frozen-pack berries are darker and the texture tougher than those packed in syrup.

Strawberries frozen at 18° F. in syrup ranging in concentration from 40 to 60 per cent are very satisfactory. Strawberries packed in 60 per cent syrup are the best. Practically no shrinkage is noticed in these samples. The color ranged from light brown to natural deep red. Surface discoloration is very slight and is apparent only in a few of the samples. Freezing of strawberries at 0° F. gave frozen-pack berries which are better in color, flavor and texture than those frozen at 18° F. Paraffined cartons are better containers than plain cans for strawberries. Plain tin cans discolor the berries, due probably to the reaction of tin on the anthocyan pigments of the berries. Strawberries are usually packed in enameled cans to prevent discoloration. In bulk, they are packed in wooden barrels or in 30-gallon enameled cans. Examination of the frozen packed berries after seven months in cold storage showed that strawberries can be successfully preserved without much change in flavor, color, and texture for a long time.

MANGOES

Experimental packs of fully ripe, firm mangoes, free from blemishes, bruises and anthracnose, showed that mangoes can be successfully preserved by freezing, with flavor, color, and texture closely approximating the fresh fruit.

Mangoes scooped out with a stainless spoon give a very fine frozen-pack product. In this form they look much like peaches. Sliced and quartered mangoes are also an appropriate form for packing, but the halved fruit is too large for small containers.

A syrup pack of 40° and 50° Brix gave a very satisfactory product. Those packed with plain sugar turn brownish and show pronounced surface discoloration. The flavor is poor, and is very different from that of the fresh fruit. Besides, considerable shrinkage and softening in texture occurs with the powdered sugar packed fruits. A 40 per cent and 50 per cent syrup packed showed little or no surface discoloration, and gave a very nice golden yellow color, especially when the fruits are totally immersed in syrup.

The various containers used in freezing mangoes were found to be very satisfactory. The color, flavor, and texture of the mangoes are in general very well preserved. For larger pack-

ages the one-gallon, slip-cover can used in packing ice cream proved satisfactory, although surface discoloration is present in many slip-cover gallon cans. The fruits should be entirely covered with syrup in order to prevent surface discoloration. Oak or other nonresinous wooden barrels lined with paraffin would be satisfactory for bulk shipment.

EFFECT OF TEMPERATURE ON FREEZING

The freezing of mangoes at 18°F. is not as satisfactory as at 0°F. and at —40°F. The mangoes frozen and stored at 18°F. are softer in texture and darker in color than the fruits frozen at lower temperatures. In one-gallon cans the fruits are not frozen hard and remain in a soft, semi-liquid form.

Freezing at 0°F. and —40°F. and storing at 18°F., the lowest available temperature in the Government cold storage plant gave products with very good color, flavor, and texture. The fruit retained the flavor of the fresh fruit. Mangoes frozen at 18°F. are of a softer texture than those frozen at 0° and —40°F. It took twenty-four hours to freeze the mangoes at 18°F., whereas only one to six hours are required when—40° and 0°F. are used as the freezing temperatures. Slow freezing is deleterious to the texture of the fruit, because of the possible destruction of the cells and tissues of the fruit by the slow formation of ice crystals between the cells. During freezing, water is withdrawn from the cells to the inter-cellular spaces where ice first forms. As freezing proceeds, these spaces become filed with ice and the cells are forced apart by the pressure of the ice crystals. With very low temperature (—40°F.), the entire fruit tissue freezes so suddenly that the ice crystals are formed within as well as between the cells.

Examination of the fruit after about eight months showed that mangoes can be preserved much longer if kept frozen and stored at the proper temperature.

Mangoes packed in the crushed form with 50 per cent syrup gave a very satisfactory product for making ice cream and sherbet. They can also be used as frozen fruit dessert, and for making pies, jam and jellies.

AVOCADOS

The preservation of avocados with the aid of heat has so far failed because an off flavor accompanied by considerable darkening of the pulp develops after cooking the fruit. This darkening or discoloration of the pulp in most fruits is due to the activation

of the enzyme oxidase naturally present in the fruit by the oxygen of the air with the formation of an organic peroxide, which in turn oxidizes the chromogen present in the fruit. This reaction seems to be almost instantaneous with avocados and for this reason considerable difficulty accompanies the preservation of this fruit by canning with the aid of heat.

Experiments on the preservation of avocados by freezing showed that the fruit can be successfully preserved in this way.

Halved, quartered, and sliced avocados frozen in 50 to 70 per cent syrup retained the flavor, color, and texture of the fruit. The different containers used in the freezing of avocados—namely, the sanitary and slip-cover cans and the cartons—were found to be satifactory. Surface discoloration is present in some of the samples. This can be greatly minimized by entirely submerging the fruits in syrup and packing them under vacuum. For this purpose, sanitary cans that can be sealed under vacuum would be the best type of containers for avocados.

EFFECT OF TEMPERATURE OF FREEZING

Avocados in syrup frozen at 0°F. and stored at 18°F. have a slight surface discoloration after three months in storage, but the color underneath is good. The flavor and texture are satisfactory. Those frozen at —40°F. and later stored at 18°F. are better in texture and flavor than those frozen at 18°F. Storage of the frozen avocados at a lower temperature, say not above 10°F., will preserve the color, flavor, and texture of the fruit better. Avocado pulp passed through a grinding machine and packed with powdered sugar in the proportion of 2:1 gave a product suitable for ice cream and sherbets. Taken alone or with cream, it makes a very nice frozen fruit dessert. The pulp should be packed immediately after crushing to prevent much darkening due to oxidation.

LANZONES

Experiments on the preservation of lanzones showed that the fruit can be successfully preserved by freezing. Only seedless segments should be packed. A 70 per cent syrup was found satisfactory for lanzones, they being acid. The different kinds of containers used in packing lanzones, namely, the sanitary and slip-cover cans, and the cartons were found to be satisfactory.

Freezing temperatures of 0° and —40°F. and storage at 18°F. were very satisfactory for lanzones. The color of the frozen

fruit is white and no surface discoloration occurs. If the cores of the segments are not removed, this part turns brown. The texture of the fruit is very good.

Experiments on the freezing of whole lanzones (in bunch), alone or with syrup, gave a product with a good color and flavor, but the skin quickly turns brown upon exposure to the air. The texture is quite soft, after the fruit is defrosted.

ATES

Ates pulp frozen with or without seeds in 20 to 60 per cent syrup in cartons and sanitary cans gave a product with a very good color, flavor, and texture. It is excellent for ice cream or when taken alone as a frozen fruit dessert. Freezing at 40°F. and storage at 18°F. gives a more satisfactory product, the fruit retaining the delicate aroma of the fresh fruit. The frozen ates can be kept in good condition for a long time. A mechanical separator that will rapidly separate the seeds from the pulp will be very desirable.

GUAVAS

Fully ripe, sliced guavas, with the seeds removed, frozen in sanitary cans and cartons in 70 per cent syrup gave a product with very good color, flavor, and texture. Freezing and storage at 18°F. is satisfactory for guavas. Frozen guava pulp is excellent for ice cream and sherbets or may be eaten as frozen fruit dessert. Guavas with seeds are also satisfactory in color, flavor, and texture.

YOUNG COCONUTS

Grated or spoon-scooped young coconuts (without including the red skin) and frozen with 40 to 50 per cent syrup made with or without any coconut water in sanitary cans or cartons gave a product that resembled coconut sherbet in flavor. The color and texture are very good. Frozen coconut can be kept for a long time at 18°F. without danger of injuring the flavor, color, and texture.

PINEAPPLES

Sliced pineapple frozen in 50 per cent syrup in sanitary and slip-cover cans and cartons at 18°F. gave a product with a very good color, texture, and flavor. The frozen fruit retained the natural fresh flavor of the pineapple, and the proteolytic enzyme present in the fresh fruit, which is destroyed in the canned fruit. Any type of container is found to be satisfactory for pineapples, although a vacuum pack would be preferable. The

texture will also be better if a lower freezing temperature is employed, say 0°F. or below.

NANGKAS AND LEMASAS

Nangka and lemasa pulp with the seeds removed, frozen at 18°F. with 50 to 60 per cent syrup, gave a product that retained the flavor, color, and texture of the fresh fruit. Any type of container was found satisfactory for nangkas and lemasas. The frozen fruit was found to be excellent after five months in cold storage at 18°F. The frozen pack fruits were found to be good for ice cream and sherbet making.

CHICOS

Sliced chicos frozen in 40 per cent syrup at 0°F. gave a product that possessed the flavor, color, and texture of the fresh fruit. Both sanitary cans and cartons are good containers for chicos. There is no surface discoloration and shrinkage in volume. The fruit is excellent as a frozen fruit dessert.

ZAPOTES

Fully ripe zapote pulp that has been passed through a 60-mesh sieve and packed with plain sugar in the proportions of 1:1, 2:1, and 3:1 showed that zapotes can be successfully preserved by freezing. Plain slip-cover gallon cans and cartons are satisfactory for zapote pulp. A freezing temperature of 0°F. is correct. The flavor of the fresh fruit is retained and is excellent for ice cream and sherbets. The 2:1 pack, which means 2 parts pulp plus 1 part sugar, is very good for ice cream. One pint of the frozen mixture to a gallon of ice-cream mix produced a delicious ice cream very nearly approximating in color and flavor chocolate ice and coffee ice cream.

THE UTILIZATION OF SOME FROZEN PACK PHILIPPINE FRUITS IN ICE CREAM MAKING

Out of the several hundred varieties of Philippine fruits, only a few have actually been used for making fruit ice creams, among which are mangoes, ates, and ube.

Ube ice cream and ube sherbet are sold the year round by all ice-cream manufacturers in Manila, other fruits being only offered to the public during the particular fruit season.

The sale of many kinds of fruit ice creams all the year round is now made possible through the preservation of the fruits during the fruiting season, either by the sterilization of the fruits

with sugar syrup in glass containers, or by freezing the fruits in syrup in tin or paraffined paper containers at temperatures ranging from 0 to 15°F.

Experience has demonstrated that sterilization of fruits with syrup tends to minimize or alter to a more or less extent the real flavor and aroma of the natural fruit, making it necessary for the ice cream manufacturers to use double and sometimes triple the amount of the sterilized fruit for flavoring the ice cream; and even then the ice cream produced is not so good as that prepared with fresh fruit.

Two methods of freezing fruits for ice cream making can be used, as follows:

a. The sorted fruit is blanched, peeled, seeds removed, transferred to the clean container and covered gradually with 40 to 60 per cent syrup to exclude the air, sealed tightly, and transferred to the chilling room.

b. The sorted fruit is blanched, peeled, seeds removed, crushed in a meat crusher and mixed with granulated white sugar in different proportions, then transferred to the clean container, sealed and chilled.

The second method has the advantage that more fruit can be stored in the minimum quantity of containers, thus taking less space in the storage room. Another advantage is that in flavoring ice cream, a less amount of the crushed fruit is necessary and less sugar and water are added to the mix, resulting in a saving of refrigerant during the process of freezing the ice cream.

The advantages of the first method are that the whole, halved or quartered fruit shows less tendency to be broken by the blades in the ice cream freezer and the finished ice cream shows large pieces of fruits. Some customers prefer to have the fruits incorporated in the ice cream in this form.

The following frozen pack Philippine fruits were found satisfactory for ice cream making:

AVOCADOS

Six to eight avocados (Cardinal variety) preserved in 60 per cent syrup are enough to flavor 10 gallons of finished ice cream. A little certified food green color can be added to enhance the appearance of the finished product. The ice cream obtained has a nice smooth body and texture with a unique taste that distinguishes it from others. This kind of ice cream is considered

delicious in American homes. Nutrition specialists have recommended it as an ideal protein food.

ATES

This fruit has a delicate illusive aroma, making it necessary to use quite a number of fruits to flavor a gallon of ice cream. Another difficulty encountered in its use is the presence of seeds, which are rather difficult to remove. A specially designed seed remover would be most welcome.

From 150 to 200 medium-sized ates are required to flavor 10 gallons of milk sherbet; and one-fourth more than the above quantity for flavoring 10 gallons of ice cream.

Some ice cream manufacturers add the whole fruit, pulp and seeds, to the ice cream mix but the resulting ice cream is troublesome to eat on account of the seeds.

CHICOS

Chico ice cream and chico sherbet are not yet popular. So far as we know, no ice cream manufacturer has given any attention to this fruit, in spite of its popularity among the Filipinos and its availability.

Chico sherbet is a good palatable dessert, preserving the delicate aroma of the fruit.

About 150 ripe regular-sized chicos, preserved in 40 per cent syrup in cold storage, are enough to flavor 10 gallons of finished sherbet. No color should be added, as the tiny pieces of the fruit look more attractive in the creamy milk sherbet.

Chicos and ates impart a slightly rough texture to the finished ice cream. This is due to their grainy pulp. In the case of ates, this defect can be avoided by carefully removing the pulp from the skin, without taking any of the meat close to the skin. Certain strains of chicos, however, have very finely grained fruit pulp.

GUAVAS

During the guava season, from July to November, a local company has succeeded in preparing guava sherbet of good quality; at one time more than 100 gallons were sold in a month.

A hundred regular-sized guava fruits (the white skin variety mixed with one-fourth of the green skin harder variety) are blanched for one minute in boiling water, and then drained quickly. They are then cut into halves, without being peeled, and the

seeds are removed completely with a curved spoon. The meat is run through a meat chopper and the pulp weighed and mixed with an equal amount of granulated white sugar.

This quantity is enough to flavor 10 gallons of milk sherbet. Some green color can be added to make it more attractive.

GUAYABANO

This fruit has more aroma and flavor than ates or anonas. Its sour taste make it ideal for salad purposes, but not so good for ice cream making; although several people have shown a liking for guayabano sherbet.

The guayabano is specially adapted for water ices, and a good-sized fruit is enough to flavor 1 gallon of guayabano water ice. In making this frozen product it is unnecessary to add citric acid, as the guayabano is sour enough to impart the characteristic acid taste required in fruit ices.

JACK FRUIT (NANGKA)

A good-sized nangka should give from 1.5 to 2 kilos of fruit meat. This meat is either preserved in 60 per cent syrup and placed at once in a 5°F. room or pulped in a meat shopper and then mixed with sugar in the proportion of 2 parts fruit to 1 part sugar.

From 4 to 6 kilos of the edible meat or its equivalent in the preserved state is necessary to flavor 10 gallons of sherbet. Unlike mango, nangka sherbet preserves the original flavor and aroma after several months of storage.

MANGO

This fruit makes wonderful sherbet and water ice, and is also satisfactory for ice cream making.

From 18 to 24 good-sized ripe mangoes are enough to flavor 10 gallons of milk sherbet, or 7 gallons of water ice. A bit of yellow certified food color improves the appearance of the finished product.

In the utilization of mangoes, either fresh or frozen, for the manufacture of frozen desserts, these should be made and eaten fresh because it has been found that mango sherbet or mango water ice kept at freezing temperature for periods longer than five days develop a decided turpentine taste, which although not repulsive is quite different from the original fresh mango flavor.

UBE

Ube, because of its characteristic and mild taste, is largely used for ice cream making. Ubes are first cooked, preferably in a pressure cooker, at 5 pounds pressure for one-half to one hour, depending upon the amount of tuber being cooked. The cover of the cooker should not be removed until the temperature has returned to normal in order not to lose any of the aroma of the tuber.

The cooked tuber is then peeled, cut into small pieces, run through a meat chopper and mixed with one-third its weight of sugar, transferred into tin containers and chilled at 5°F.

From 6 to 8 kilos of ube or its equivalent of the preserved tuber are sufficient to flavor 10 gallons of ice cream or sherbet. A tinge of purple color is added to the finished product.

ZAPOTE

This plant, which hitherto has had no commercial value, grows well in many places of the Philippines. It bears many fruits of high food value. The fruit pulp, after the seeds have been removed, is mixed with one-third its weight of sugar, and preserved at 5°F.

From fifteen to twenty fruits or their equivalent of preserved pulp is required to flavor and color 10 gallons of finished sherbet.

The zapote has a rich coffee brown color and a smooth texture. The flavor is similar to chico sherbet.

LANZONES

This fruit does not blend well in either ice cream or milk sherbet, but makes very good water ice. Two hundred large lanzones or 400 small or medium-sized fruits are enough to flavor 7 gallons of finished fruit ice.

It is necessary to reject the segment or segments having large seeds, as otherwise a bitter taste will be imparted to the finished product. The selected segments are crushed gently before mixing them with the water-ice base.

SUMMARY AND CONCLUSIONS

1. Various Philippine fruits, namely: strawberries, mangoes, avocados, lanzones, ates, guavas, young coconuts, pineapples, nangkas, lemasas, chicos, and zapotes have been successfully preserved by freezing at 18°F., 0°, and —40°F.

2. In most of the frozen pack fruits studied the natural flavor of the fresh fruits had been retained or improved with very

good preservation of the original color and texture after defrosting.

3. Freezing at 0°F. and —40°F. gave frozen pack products possessing better flavor, color and texture than those frozen at 18°F. This is especially more pronounced in the case of mangoes and avocados.

4. Air-tight containers are preferable to the friction or slip-cover cans or cartons, but the latter are also satisfactory.

5. Surface discoloration is apparent in many of the samples examined. This may be prevented by complete immersion in syrup, and could be entirely eliminated by vacuumizing the containers before closing.

6. A syrup pack of from 40° to 60° Brix is very satisfactory depending upon the nature of the fruits packed. Syrup pack has many advantages over the dry sugar pack method.

7. The principal justification for freezing as a means of preserving fruits lies in the better preservation of color, flavor and texture. Seasonal fruits can thereby be made available throughout the year. Frozen pack Philippine fruits open up a promising export industry.

8. Frozen fruits have varied uses. They are excellent for ice cream and sherbet making. Avocado and zapote ice creams prepared from the frozen fruit pulp are pronounced excellent. When taken alone, frozen pack fruits may be used as a frozen fruit dessert. They are also useful for salads, pie and cake fillers, and can easily be made into jams, jellies and preserved and crystallized fruits.

9. Methods of commercially utilizing frozen pack Philippine fruits have also been discussed.

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TABLE 1.—*Experiments on the preservation of Baguio strawberries by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
Feb. 19	Sorted, hulled, washed, drained, and packed with refined cane sugar in the proportion of 1.1.	....	Sanitary can No. 2	5	18	18	0.5
Feb. 19	Sorted, hulled, washed, drained and packed with sugar in the proportion of 2.1.	....	Nestrite carton	4	18	18	0.5
Mar. 1	Sorted, hulled, washed, drained and packed with syrup	40	Sanitary can No. 2	10	18	18	0.5
Mar. 4	....do	40	Nestrite carton	12	18	18	1
Mar. 4	....do	50	....do	6	18	18	1
Mar. 4	....do	60	....do	6	18	18	1
Mar. 11	....do	40	....do	7	18	18	2
Mar. 11	....do	50	Sanitary can No. 2	8	18	18	2
Mar. 11	....do	60	....do	10	18	18	2
Mar. 17	....do	60	....do	15	18	18	3
Mar. 18	....do	60	Nestrite carton	16	0	18	4
Mar. 21	....do	60	....do	21	0	18	5
Mar. 29	....do	60	....do	13	0	18	5
April 12	....do	60	....do	12	0	18	6
April 19	....do	60	....do	14	0	18	7

Packed and frozen	Treatment	Observations and sampling tests: Surface discoloration	Color	Flavor	Size and texture of fruit	Rating after defrosting
1932						
Feb. 19	Sorted, hulled, washed, drained and packed with sugar in the proportion of 1:1.	Slight	Brownish	Fair, over sweet	Much shrinkage; soft	Poor.
Feb. 19	Sorted, hulled, washed, drained and packed with sugar in the proportion of 2:1.	....do	Good	Good	Little shrinkage; fair	Good.
Mar. 1	Sorted, hulled, washed, drained and packed with syrup.	None	Slightly dull red	Very good	No shrinkage; slightly soft	Do.
Mar. 4	....do	....do	Natural deep red	Natural but tart	....do	Do.
Mar. 4	....do	....do	....do	Very good	No shrinkage and disintegration.	Very good.
Mar. 4	....do	....do	Very good	Excellent	Good	Excellent.
Mar. 11	....do	Slight	....do	Somewhat tart	No shrinkage; slightly soft	Good.
Mar. 11	....do	None	Dull brown	Excellent	....do	Very good.
Mar. 11	....do	....do	....do	....do	....do	Do.
Mar. 17	....do	....do	....do	Very good	No shrinkage; texture good	Good.

Mar. 18	.....do.	.....do.	Natural deep red	Excellent	No shrinkage and disintegration; firm texture.	Excellent.
Mar. 21	.....do.	Slight	.....do.	Very good	.....do.	Very good.
Mar. 29	.....do.	None	.....do.	Excellent	.....do.	Excellent.
April 12	.....do.	Slight	Dark red	Very good	.....do.	Very good.
April 19	.....do.	.....do.	.....do.	.....do.	No shrinkage; slightly soft	Good.

TABLE 2.—*Experiments on the preservations of mangoes by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
Mar. 11	Washed, pealed, pitted, and sliced; packed with sugar in the proportion of 2:1	....	Nestrite carton	6	18	18	1.5
April 4	Washed, peeled, pitted, and sliced	40	.....do.	13	18	18	30
April 4	.....do.	50	.....do.	8	18	18	30
April 5	Washed, peeled, pitted, and cubed	40	Sanitary can No. 2	10	18	18	2
April 5	Washed, peeled, and halved	50	.....do.	10	18	18	2
April 13	.....do.	50	Nestrite carton	10	0	18	2.5
April 14	Washed, peeled, halved, and cubed	50	.....do.	5	40	18	2
April 19	Washed, peeled, halved, and quartered	50	.....do.	28	40	18	4
April 27	Washed, peeled, pitted, and sliced	40	.....do.	15	0	18	3
April 27	.....do.	50	.....do.	12	0	18	3
April 29	.....do.	40	.....do.	10	0	18	5
May 3	Washed, peeled, pitted, and quartered	50	.....do.	39	0	18	4
May 4	Washed, peeled, and halved	50	Slip-cover gallon can	19	0	18	4
May 20	Washed, peeled, pitted, and sliced	50	Nestrite carton	12	0	18	4
May 27	Washed, peeled, pitted, and quartered	50	Slip-cover gallon can	2	18	18	3
May 28	.....do.	50	Nestrite carton	28	18	18	4
May 31	Washed, peeled, halved and crushed plus 50 per cent sugar	....	Slip-cover gallon can	9	0	18	4
June 7	Washed, halved, and scooped out with stainless spoon	40	.....do.	9	0	18	6
June 9	.....do.	40	Sanitary can No. 2	23	40	18	6
June 9	.....do.	50	Nestrite carton	20	40	18	6

TABLE 2.—*Experiments on the preservations of mangoes by freezing*—Continued

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
Mar. 11	Washed, peeled, pitted, and sliced; packed with sugar in the proportion of 2:1.	Much	Dark brown	Poor	Very soft; considerable shrinkage.	Poor.
April 4	Washed, peeled, pitted, and sliced	Slight	Brownish yellow	Good	No disintegration; some shrinkage.	Fair.
April 4	do	None	Golden yellow	Very good	No shrinkage; texture firm	Good.
April 5	Washed, peeled, pitted, and cubed	do	do	Good	do	Do.
April 5	Washed, peeled, and halved	do	do	do	No shrinkage; slightly soft	Fair.
April 15	do	Slight	Brownish	Fair	Slightly shrinkage; slightly soft.	Do.
April 19	Washed, peeled, halved, and cubed	None	Golden yellow	Excellent	No shrinkage; firm	Excellent.
April 19	Washed, peeled, halved, and quartered	do	do	do	No shrinkage, no disintegretion very good texture.	Do.
April 27	Washed, peeled, pitted, and sliced	do	do	Very good	do	Do.
April 27	do	do	do	Excellent	do	Do.
April 19	do	do	do	Very good	do	Very good.
May 3	Washed, peeled, pitted, and quartered	do	do	do	do	Do.
May 4	Washed, peeled, and halved	Slight	Brownish	Good	Slight shrinkage. Slightly soft.	Fair.
May 20	Washed, peeled, pitted, and sliced	None	Golden yellow	Very good	No shrinkage; firm	Very good.
May 27	Washed, peeled, pitted, and quartered	Much	Brownish yellow	Poor	Much disintegration and shrinkage; poor texture	Poor.
May 28	do	None	Golden yellow	Good	No shrinkage; good texture	Good.
May 31	Washed, peeled, halved, and crushed plus 50 per cent sugar.	Much	Dark brown	Fair	Slight shrinkage; texture soft	Fair.
June 7	Washed, halved, and scooped out with stainless spoon.	Slight	Golden yellow	Excellent	No shrinkage; texture good	Excellent.
June 9	do	None	do	do	No shrinkage; very good	Do.
June 9	do	Very slight	do	do	do	Good.

TABLE 3.—*Experiments on the preservation of avocados by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			° *F.*	° *F.*	*Months*
May 26	Washed, peeled, pitted, and halved	40	Sanitary can No. 2	8	0	18	1
June 9	Washed, peeled, pitted, and sliced	50	....do	6	0	18	
June 9	....do	50	Nestrite carton	6	0	18	1
June 9	....do	40	....do	7	0	18	1
July 21	....do	60	Sanitary can No. 2	5	0	18	1
July 22	....do	60	....do	19	0	18	2
July 23	Washed, peeled, pitted, and halved	60	Slip-cover gallon can	9	0	18	3
July 25	Washed, peeled, pitted, and sliced	60	....do	8	0	18	1
Aug. 1	Washed, peeled, pitted, and quartered	60	....do	17	0	18	2
Aug. 2	....do	70	....do	8	0	18	3
Aug. 3	....do	70	Nestrite carton	19	0	18	2
Aug. 4	....do	60	Slip-cover gallon can	9	0	18	2
Aug. 5	....do	60	Nestrite carton	8	40	18	3
Aug. 6	....do	60	Sanitary can No. 2	11	40	18	3
Aug. 8	Washed, peeled, pitted and crushed in a meat grinder; packed with sugar in proportion 1:1.	Slip co.	Slip-cover gallon can	5	0	18	3 3
Aug. 9	Washed, peeled, pitted, and crushed in a meat grinder; packed with sugar in proportion 2:1.	....	Nestrite carton	13	0	18	3
Aug. 10	Washed, peeled, pitted and crushed in a meat grinder; packed with sugar in the proportion of 3:1.	....	Sanitary can No. 2	5	0	18	3

TABLE 3.—*Experiments on the preservation of avocados by freezing*—Continued

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
May 26	Washed, peeled, pitted, and halved	Slight	Dark green	Fair	Some disintegration; texture slightly soft.	Fair.
June 9	Washed, peeled, pitted, and sliced	do	Olive green	Good	Some disintegration; texture fair.	Good.
June 9	do	Much	Dark green	Poor, somewhat stale	Much shrinkage; soft	Poor.
June 16	do	do	Dull green	Poor, overipe	do	Do.
July 21	do	None	Bright green	Good	Little shrinkage; good texture.	Good.
July 22	do	do	do	Excellent	No shrinkage; texture good	Excellent.
July 23	Washed, peeled, pitted, and halved	Slight	Dull green	Good	Slight disintegration texture	Good.
July 25	Washed, peeled, pitted, and sliced	None	do	Very good	No disintegration; good texture.	Very good.
Aug. 1	Washed, peeled, pitted, and quartered	do	do	Good	do	Do.
Aug. 2	do	do	do	Fair, oversweet	Incompletely frozen syrup; too tick texture soft.	Poor.
Aug. 3	do	Slight	do	Over sweet	Slight disintegration; texture fair.	Fair.
Aug. 4	do	None	Bright green	Good	No disintegration texture; good.	Good.
Aug. 5	do	do	do	Very good	do	Excellent.
Aug. 6	do	do	do	Excellent	Very good	Do.
Aug. 8	Washed, peeled, pitted and crushed in a meat grinder; packed with sugar in proportion 1:1.	Slight	Dark green	Fair, too sweet	Some shrinkage; quite soft	Poor.
Aug. 9	Washed, peeled, pitted, and crushed in a meat grinder; packed with sugar in proportion 2:1.	do	Dull green	Good	No shrinkage; good texture	Good.
Aug. 10	Washed, peeled, pitted, and crushed in a meat grinder; packed with sugar in proportion of 3:1.	None	do	do	No shrinkage; good	Do.

TABLE 4.—*Experiments on the preservation of lanzones by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			° *F.*	° *F.*	*Months*
Aug. 30	Peeled, segmented, sorted, and packed with syrup	60	Nestrite carton	7	0	18	15
Aug. 30	Peeled, segmented, sorted, and packed with syrup; core at center removed	60	Sanitary can No. 2	6	0	18	15
Sept. 21	Washed, and packed without peeling the fruit and frozen		do	2	—40	18	18
Sept. 21	Washed and packed in syrup with peeling	70	Nestrite carton	2	—40	18	18
Sept. 21	do	80	do	2	—40	18	18
Sept. 21	Washed, peeled, and all segments packed in syrup	70	do	4	—40	18	18
Sept. 21	do	80	do	2	—40	18	18
Sept. 21	Washed, peeled, segmented, and sorted; only seedless segments packed in syrup	70	do	10	—40	18	30
Oct. 3	Washed and packed whole with peeling in syrup	60	Slip-cover gallon can	2	0	0	30
Oct. 3	do	50	do	2	0	0	30
Oct. 3	do	40	do	2	0	0	30
Oct. 4	Washed, peeled, segmented, and sorted; seedless segments cut through the seed to detect presence of small seeds; the cut portions packed in syrup.	70	Sanitary can No. 2	12	—40	18	60

TABLE 4.—*Experiments on the preservation of lanzones by freezing*—Continued

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
Aug. 30	Peeled, segmented, sorted, and packed with syrup.	Slight	Brown at the core	Poor; bitter	No shrinkage, slight disintegration; good texture.	Poor.
Aug. 30	Peeled, segmented, sorted, and packed with syrup; core at center removed.	None	Good	Poor; slightly bitter	do	Fair.
Sept. 21	Washed, and packed without peeling the fruit and frozen.	Much	Brown skin; pulp white.	Insipid	Soft	Very poor.
Sept. 21	Washed and packed in syrup with peeling.	Slight	Good	Good	No shrinkage; slightly soft	Good.
Sept. 21	do	None	do	Oversweet	Slight shriveling; soft after thawing.	Poor.
Sept. 21	Washed, peeled, and all segments packed in syrup.	do	do	Poor; bitter	No shrinkage; texture good	do
Sept. 21	do	do	do	Poor; slightly bitter	do	do
Sept. 21	Washed, peeled, segmented, and sorted; only seedless segments packed in syrup.	do	Very good	Good	do	Very good.
Oct. 3	Washed, and packed whole with peeling in syrup.	Much	Brownish	Poor; flat	Slight shrinkage; slightly soft.	Poor.
Oct. 3	do	do	do	do	do	do
Oct. 3	do	Slight	do	Poor; acid	Very soft	Very poor.
Oct. 4	Washed, peeled, segmented, and sorted; seedless segments cut through the seed to detect presence of small seeds; the cut portions packed in syrup.	None	Good	Excellent	No shrinkage; good	Excellent.

TABLE 5.—*Experiments on the preservation of ates by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			° *F.*	° *F.*	*Months*
July 13	Opened, scraped with a spoon, and packed with the seeds in syrup	70	Sanitary can No. 2	4	—40	18	0.5
Aug. 6	do	60	do	4	—40	18	1
Sept. 24	Opened, scraped with a spoon, and the seeds removed by sieving, and the pulp packed in syrup.	10	Nestrite carton	9	—40	18	1
Sept. 26	do	20	Sanitary can No. 2	6	—40	18	1
Sept. 27	do	20	do	8	—40	18	2
Sept. 28	do	20	Nestrite carton	12	—40	18	2

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
July 13	Opened, scraped with a spoon, and packed with the seeds in syrup.	None	Very good	Good; oversweet	No shrinkage; good	Very good.
Aug. 6	do	do	do	Excellent	do	Excellent.
Sept. 24	Opened, scraped with a spoon, and the seed removed by sieving, and the pulp packed in syrup.	do	Slightly darker	Natural; somewhat flat	No shrinkage	Good.
Sept. 26	do	do	Good	Natural; good	do	Very good.
Sept. 27	do	do	do	Very good	do	Very poor.
Sept. 28	do	do	Very good	do	do	Excellent.

TABLE 6.—*Experiments on the preservation of guavas by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
Aug. 9	Washed, peeled, and halved	70	Nestrite carton	10	18	18	2
Aug. 21	Washed, peeled, halved, and the seeds removed with a spoon	70	Ditto	18	18	18	2
Aug. 11	do	70	Sanitary can No. 2	12	18	18	3

Packed and frozen	Treatment	Observations and sampling tests: Surface discoloration	Color	Flavor	Size and texture of fruit	Rating after defrosting
1932						
Aug. 9	Washed, peeled, and halved	None	Very good	Good	No shrinkage; good	Good.
Aug. 1	Washed, peeled, halved, and the seeds removed with a spoon.	do	do	Excellent	do	Excellent.
Aug. 11	do	do	do	do	do	do

TABLE 7.—*Experiments on the preservation of young coconuts (buko) by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			°*F.*	°*F.*	*Months*
July 6	White meat grated and packed in plain syrup	40	Sanitary can No. 2	10	0	18	2
July 8	White meat scraped with spoon and packed in plain syrup	40	do	12	0	18	2
Aug. 11	do	50	do	8	0	18	3
July 12	White meat scraped with spoon and packed in syrup made of coconut water	50	do	10	0	18	2
July 14	do	50	Nestrite carton	9	0	18	2

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
July 6	White meat grated and packed in plain syrup.	None	Good	Very good	No shrinkage; good	Excellent.
July 8	White meat scraped with a spoon and in plain syrup.	do	do	do	do	do
July 11	do	do	do	do	do	do
July 7	White meat scraped with spoon and packed in syrup made of coconut water.	do	do	Natural; excellent	do	do
July 14	do	do	Very good	do	do	do

TABLE 8.—*Experiments on the preservation of miscellaneous fruits by freezing*

Packed and frozen	Treatment	Concentration of syrup	Container	Containers packed	Freezing temperature	Storage temperature	Age when thawed and examined
1932		° *Brix*			° *F.*	° *F.*	*Months*
Apr. 22	Pineapple; peeled, cored, and sliced	50	Sanitary can No. 2	10	18	18	5
June 16	do	60	Slip-cover gallon can	4	18	18	6
Apr. 30	Nangka; pulp washed and seeds removed	60	do	6	18	18	5
May 12	Lemasa; pulp washed and seeds removed	60	do	15	0	18	5

Packed and frozen	Treatment	Observations and sampling tests				Rating after defrosting
		Surface discoloration	Color	Flavor	Size and texture of fruit	
1932						
Apr. 22	Pineapple; peeled cored, and sliced	None	Very good	Natural; excellent	No shrinkage; good	Excellent.
June 16	do	Slight	Good	do	do	Good
Apr. 30	Nangka; pulp washed and seeds removed	do	do	Natural; good	Good; little tough	do
May 12	Lemasa; pulp washed and seeds removed	do	do	do	No shrinkage; good	do

ILLUSTRATIONS

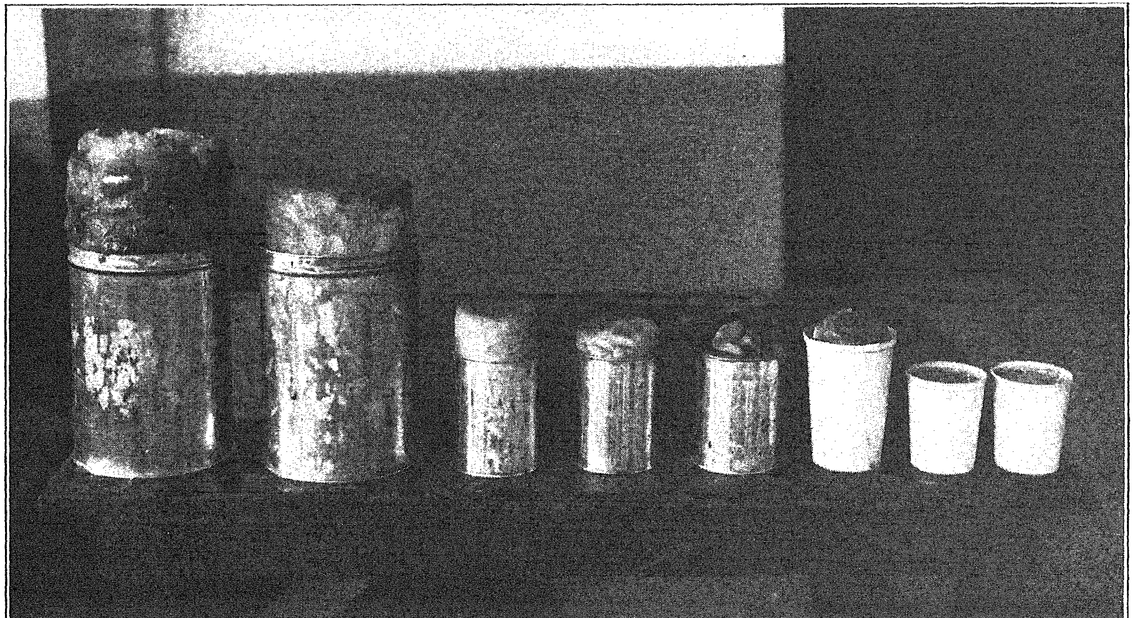
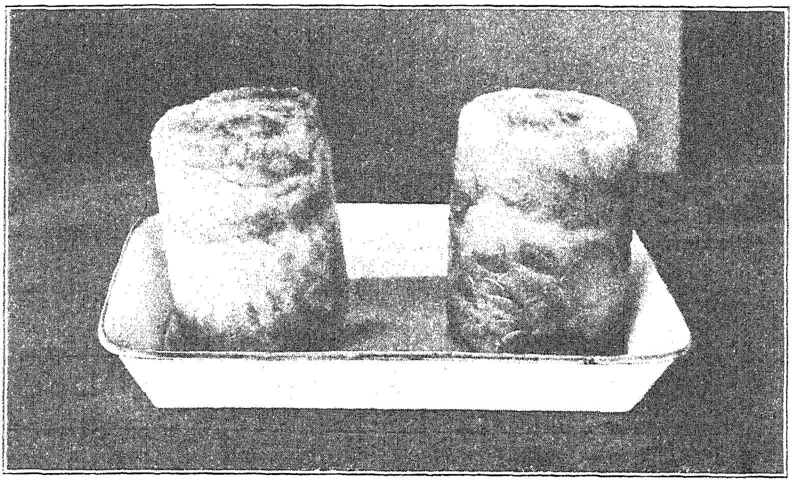
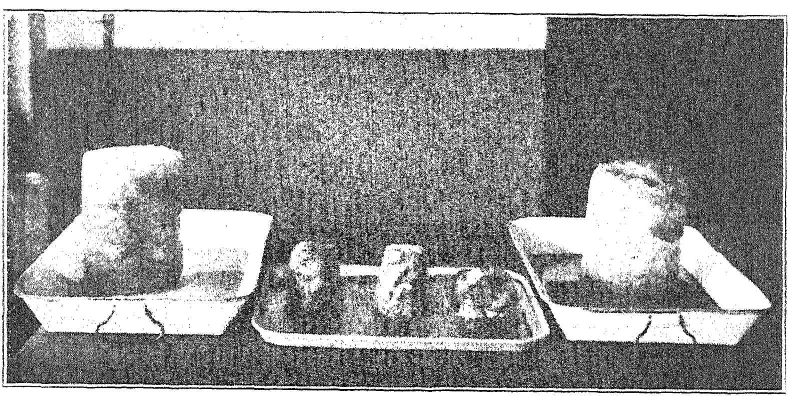


PLATE 1.—Left to right; mangoes and pineapples in gallon cans; ates, lanzones and avocados in No. 2 sanitary cans; avocados, zapotes and mangoes in Nestrite cartons.

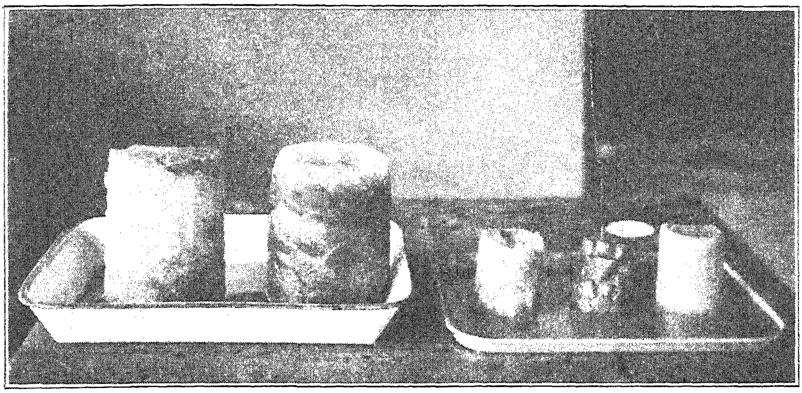


(a) Left to right: Sliced pineapple and sliced mango removed from containers.

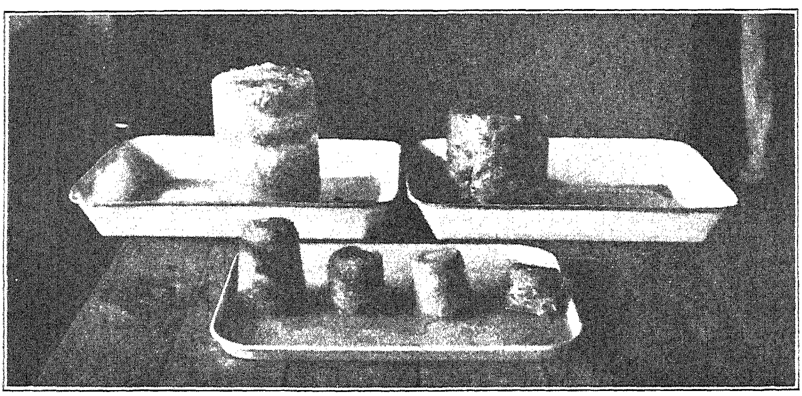


(b) Left to right: Sliced mango frozen in gallon can, zapote pulp, cubed mango, sliced avocado in Nestrite cartons, and sliced pineapple in gallon can.

PLATE II.

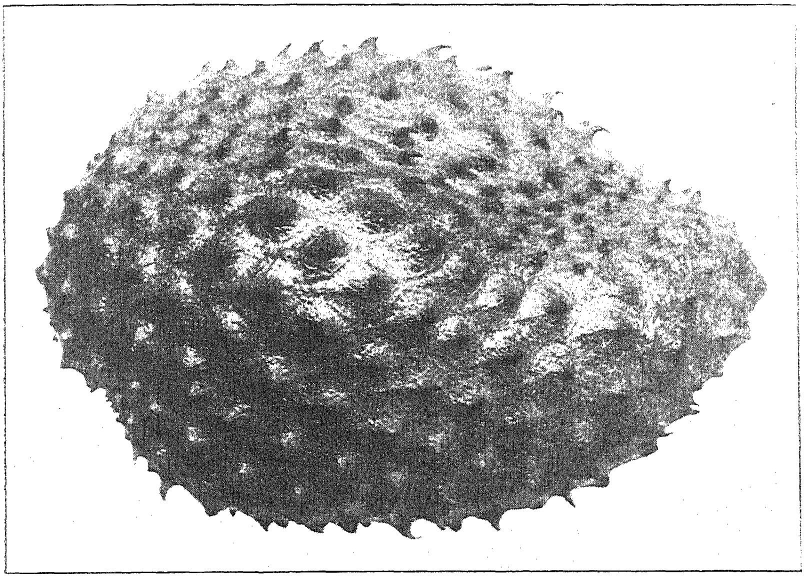


(*a*) Left to right: (1) Pineapple and mango frozen in gallon cans; lanzones, mango and ates pulp in Nestrite cartons. (2) Pineapple and mango frozen in gallon cans; lanzones, mango and ates pulp in Nestrite cartons.

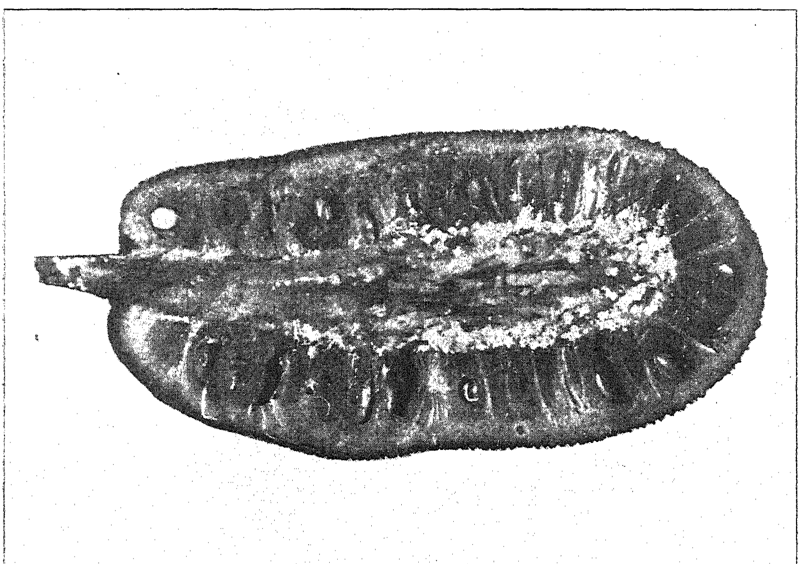


(*b*) Front picture; left to right: Mango, papaya, ates, avocado. Back picture; left to right: Pineapple, mango.

PLATE III.

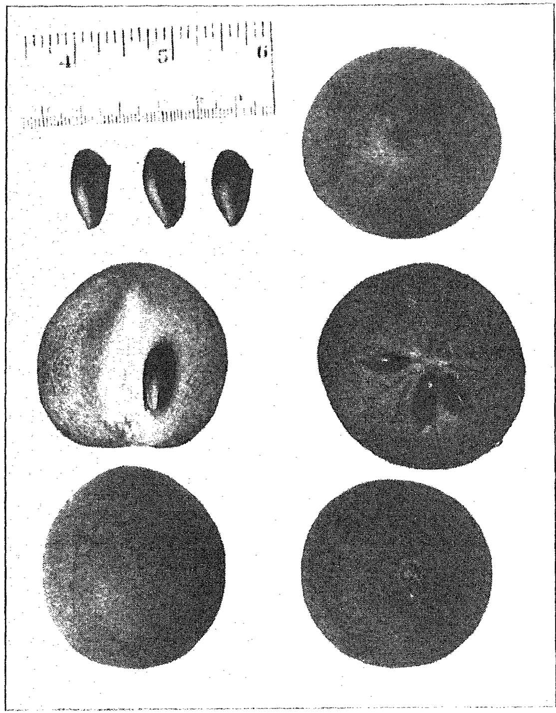


(*a*) Guayabano fruit.

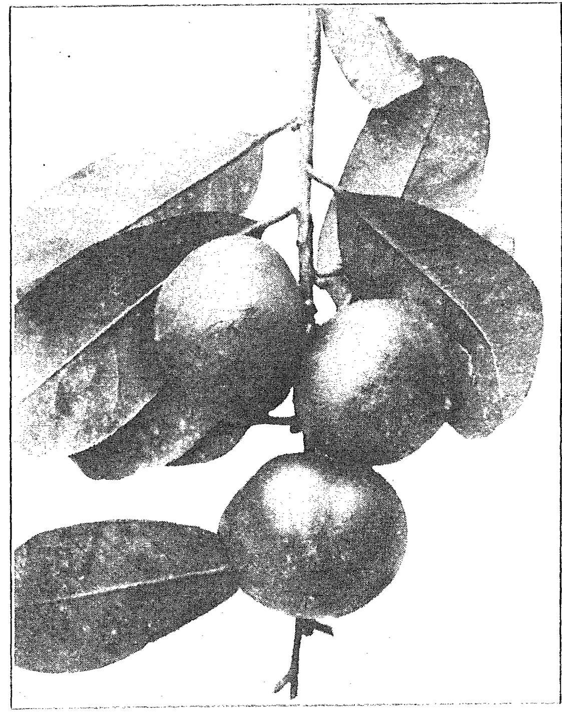


(*b*) Nangka fruit (½ fruit).

PLATE IV.

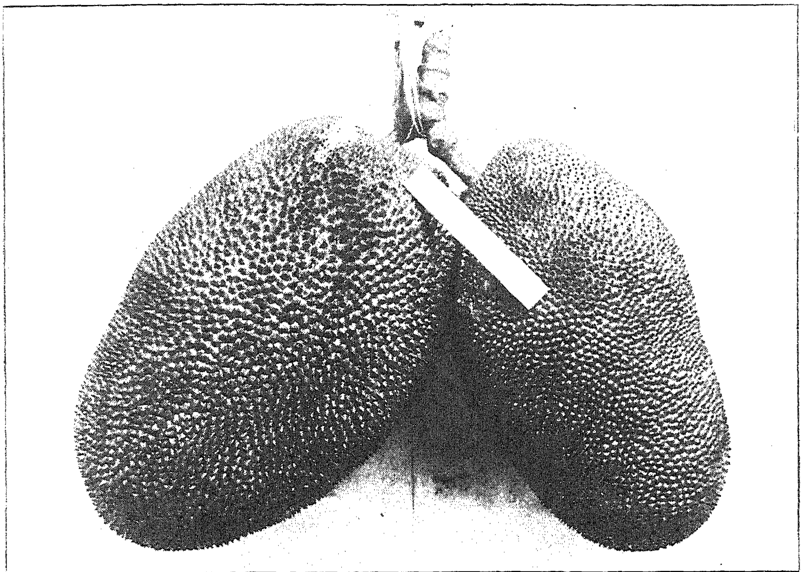


(*a*) Chico fruit.

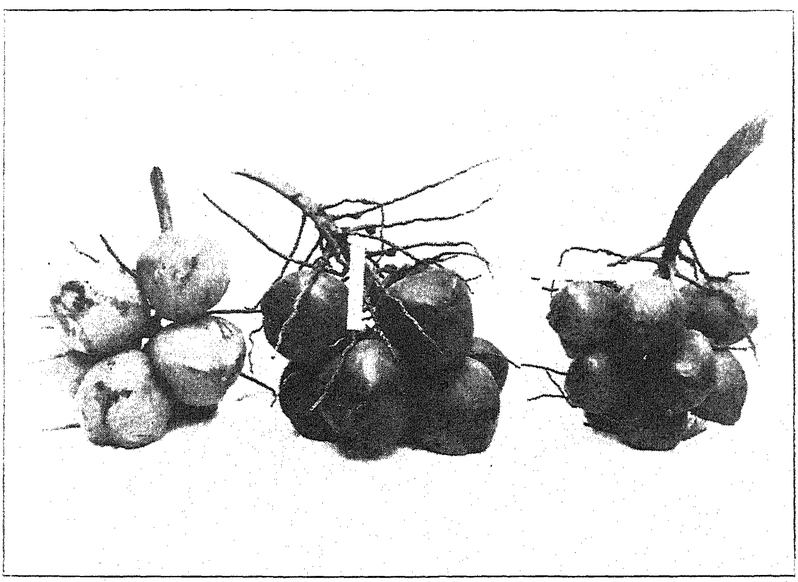


(*b*) Zapote fruit.

PLATE V.

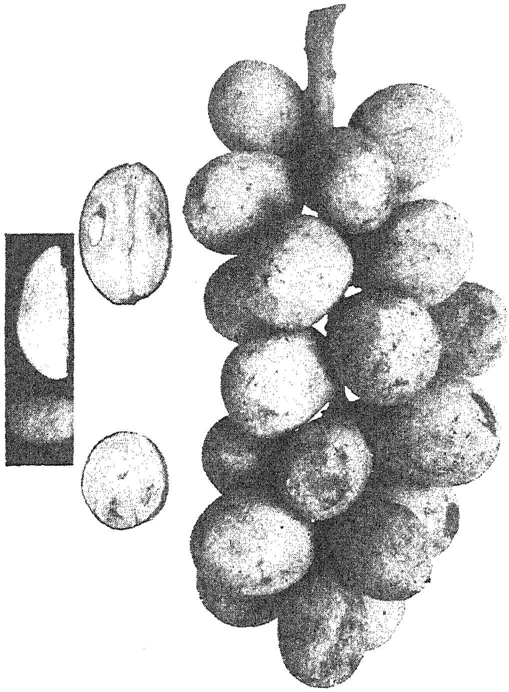


(*a*) Nangka fruits.

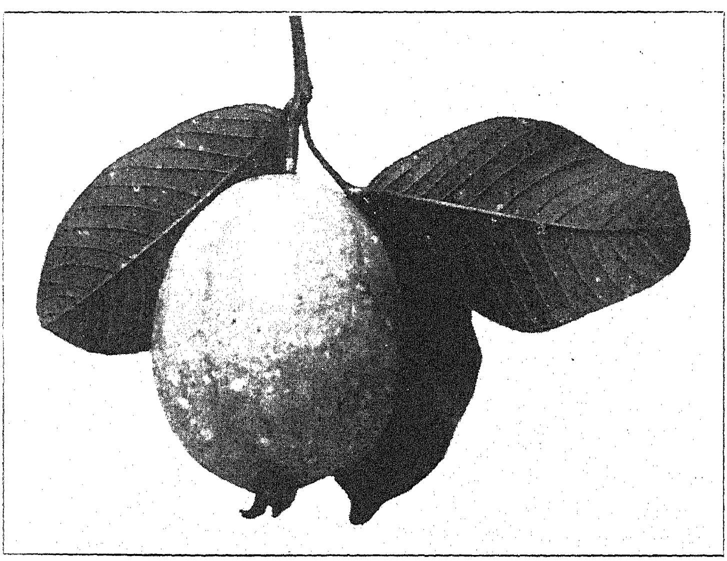


(*b*) Coconuts.

PLATE VI.

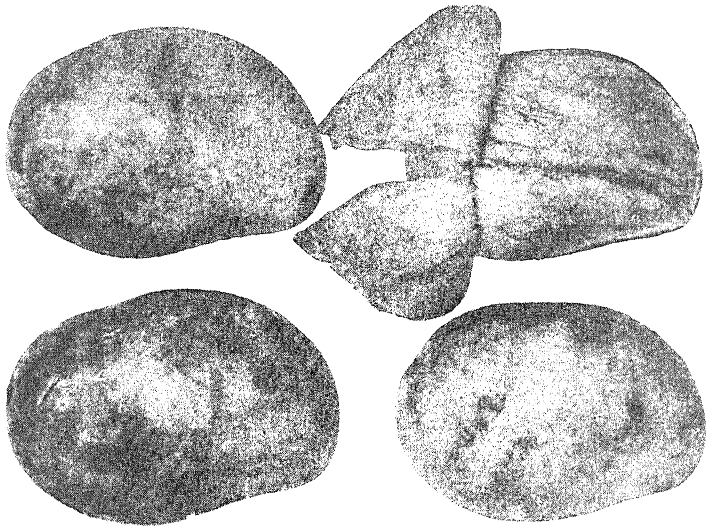


(*a*) Lanzones.

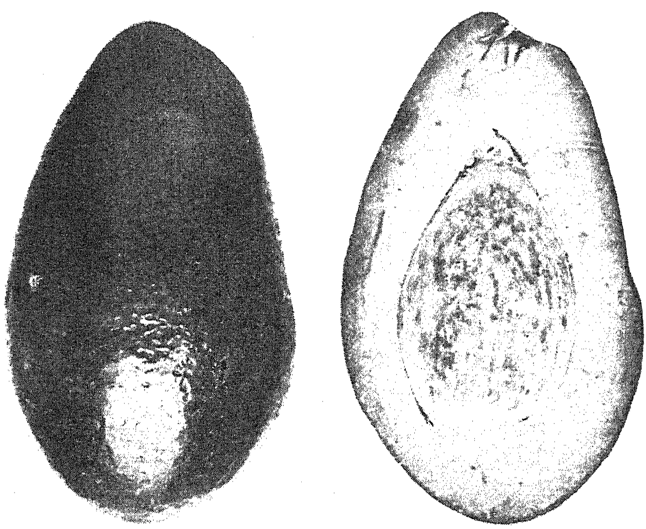


(*b*) Guava fruit.

PLATE VII.

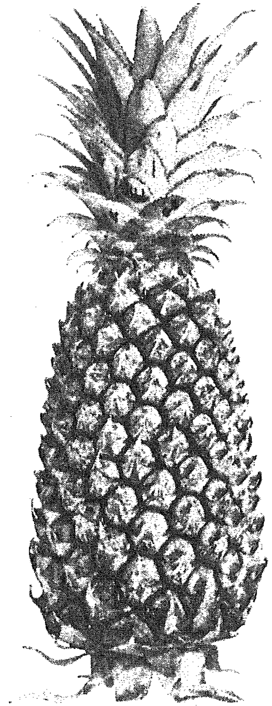


(*a*) Mangoes.

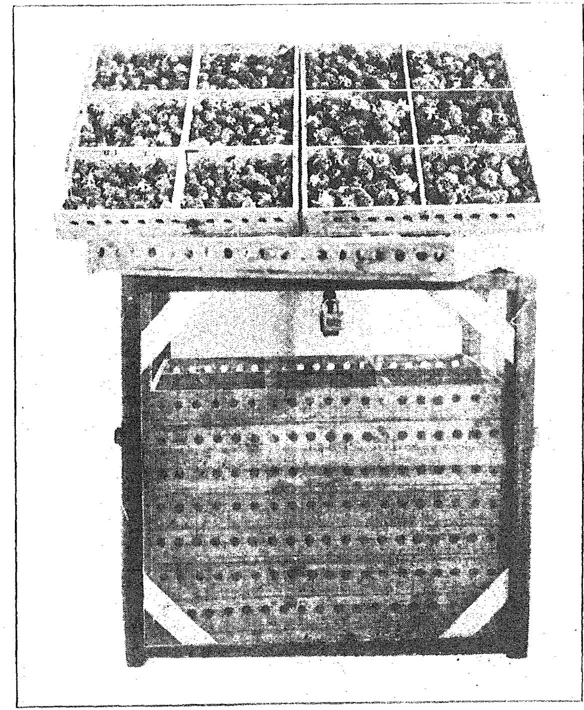


(*b*) Avocados.

PLATE VIII.



(*a*) Smooth Cayenne pineapple.



(*b*) Especially constructed crate for transporting strawberries.

PLATE IX.

THE EFFECT OF FERTILIZERS AND GRASS MULCH ON THE STRAWBERRY FIELD

By PEDRO A. RODRIGO

Of the Bureau of Plant Industry, Manila

THREE TEXT FIGURES

With the growing popularity of the strawberry (*Fragaria chiloensis*), in certain regions in the Philippine Islands, more information about its culture under local conditions will be in demand. Primarily in anticipation of this need, the experiment reported in this paper was undertaken. The work, which was done at the Baguio Semitemperate Fruit Station of the Bureau of Plant Industry, was started in July, 1931, and completed in June, 1932.

REVIEW OF LITERATURE

The common belief among strawberry growers in Baguio and in Trinidad Valley is that it does not pay to fertilize strawberries. It is their usual experience that strawberries when fertilized have an excellent vegetative growth but a poor yield. An investigation of the matter, however, disclosed the fact that the fertilizer they used almost exclusively was ammonium sulphate, the one commonly used for cabbages in the region. Such a fertilizer, while it gives good results when applied to cabbages, does not favor production of strawberries because it furnishes nitrogen only.

Rodrigo and Dirige [1] reported that a coöperator of the Bureau of Plant Industry in Trinidad Valley, Mountain Province, obtained less income from a fertilized strawberry field than from an unfertilized one of the same area. In strawberry culture in the United States, fertilizers are applied to suit the needs of the soil. Darrow [2] suggests the application of 100 to 700 pounds of phosphoric acid, 50 to 300 pounds of potash, and 50 to 200 pounds of nitrogen to one acre of strawberries.

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[1] Rodrigo, P. A., and M. Dirige, Strawberry Culture, Philip. Journ. Agr. 2 (1931) 3–13 + 4 pls.

[2] Darrow, G. M., Strawberry Culture: Eastern United States, U. S. Dept. Agr. Farmers' Bull. No. 1028 (1923).

Mulching is one of the essentials of successful strawberry culture in the United States,[3] pine needles, and straw of various kinds being commonly used for this purpose. Mulching in the United States serves to keep the fruits clean, to conserve moisture, to keep down weeds, and to prevent the soil from baking. In the Trinidad Valley, Mountain Province, the use of straw mulch in strawberry culture is not yet understood or practiced.

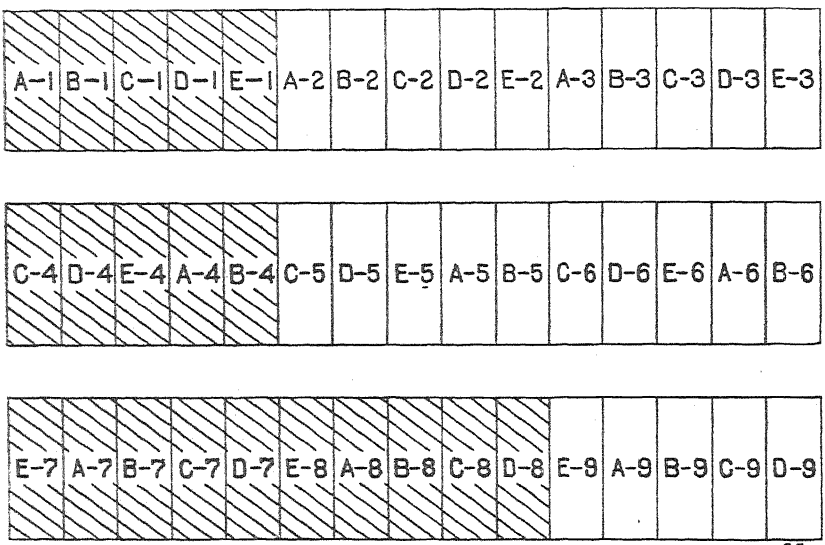

FIG 1. Graph showing the arrangement of the experimental plots. Plot A served as check; Plot B, fertilized with stable manure at 20 tons per hectare; Plots C, D, and E fertilized with a 5-10-5 commercial fertilizer at 200, 500, and 800 kilos per hectare, respectively. The shaded plots were not mulched; the rest were mulched with dry grass and pine needles.

MATERIALS AND METHODS

The field devoted to this experiment was level and fairly uniform in fertility except one corner where the surface soil had been removed when the ground was leveled. An excellent crop of soybeans was plowed under before the field was prepared for the experiment. Plots 25 square meters in area (3 by 8.34 m) were laid out, and prepared for planting as uniformly as could possibly be done.

Stable manure, and a complete fertilizer (5–10–5) applied in different amounts, were incorporated in the soil as shown in fig. 1. The fertilizer used was compounded in the station. It contained 5 per cent nitrogen, 10 per cent phosphorus, and 5

[3] Moore, J. G., Strawberry Culture in Wisconsin, Wis. Agr. Exp. Sta. Bull. No. 360 (1929).

per cent potash. Ammonium sulphate supplied the nitrogen in this fertilizer, double superphosphate furnished the phosphorus, and sulphate of potash was the source of the potassium. The stable manure was applied at the rate of 20 tons per hectare, and the other fertilizer at the rate of 200, 500, and 800 kilos per hectare. The stable manure was applied and incorporated in the soil about a week before planting. One-half of the commercial fertilizer in each treatment was applied just before planting, and the other half September 24, 1931, when the plants had recovered from the effect of transplanting. Each treatment was replicated nine times, including that for the check plots. The methods of laying off the experiment plots is shown in fig. 1.

The variety Hood River was used in this experiment. The runners were prepared for planting by pruning the roots and cutting off the leaves, except a few of the young ones. The entire field was planted in two days. The plants were set 25 cm apart in rows spaced 50 cm apart.

Early in November, 1931, plots A–2, A–3, A–5, A–6, A–9, B–2, B–3, B–5, B–6, B–9, C–2, C–3, C–5, C–6, C–9, D–2, D–3, D–5, D–6, D–9, E–2, E—3, E–6, and E–9 were mulched with dry pine needles and dry grass as indicated in fig. 1. The mulch, which was about 5 cm thick, was spread after a thorough cultivation and weeding had been done. Plots A–1, A–4, A–7, A–8, B–1, B–4, B–7, B–8, C–1, C–4, C–7, C–8, D–1, D–4, D–7, D–8, E–1, E–4, E–7, and E–8 were also cultivated and weeded but were left without any grass mulch. Fig. 1 further shows the arrangements of the mulched and the unmulched plots.

The mulched plots were weeded twice during the whole progress of the experiment, while the unmulched plots were cultivated and weeded nine times. Both mulched and unmulched plots were irrigated more or less the same. The first harvest was gathered November 24, 1931; and harvesting continued until the second week of June, 1932. The picking was done at 1- to 3-day intervals. The fruits from each plot were put in a paper bag, labeled accordingly, and then weighed and recorded.

Field observations were made of the general growth of the plants, the general quality of the berries in the field, and on the prevalence of diseases attacking the leaves and fruits under the different treatments.

EXPERIMENTS AND RESULTS

This experiment was run with two main objects; namely, to determine the effect of different amounts of commercial ferti-

lizers on the productions of strawberry, and the effect of mulch on the yield and the quality of the berries. To get data on the second point half of the fertilizer plots were mulched, and the other half left unmulched.

The data reported in this paper were obtained during the strawberry season of 1931–1932.

Field observations.—It was observed that the plants in the fertilized plots had a tendency to recover earlier from the effect of transplanting. When the plants were fully recovered, there was virtually no effect from the fertilizers on the general stand of the crop. Even when the plants were in full bearing, the different in stand was, at best, slightly in favor of the plots heavily treated with commercial fertilizers; the plants in the fertilized plots were darker green in color. On the other hand, plants that were mulched, whether fertilized or not, were decidedly bigger than the unmulched plants.

Ripening berries were attacked by certain kinds of fruit rot. This was especially true during warm moist days. The proportion of infected berries was markedly greater in the unmulched plots. Berries gathered from the mulched plots were decidedly clearner than those from the unmulched plots. The berries in the mulched plots were absolutely clean even just after a rain, or the application of irrigation water.

Tables 1, 2, 3, and 4 present the summarized results of the experiments. Table 1 gives the 15-day average yields of the different treatments, thus presenting in a graphic way the march in yield throughout the bearing period of the plants. Table 2 shows the effect of some fertilizers on strawberry production.

TABLE 1.—*Showing the average 15-day yield of strawberry as affected by mulch and commercial fertilizers*

Fertilizers applied	Mulched	Yield every 15-day period						
		Nov. 24–Dec. 8	Dec. 9–23	Dec. 24–Jan. 7	Jan. 8–22	Jan. 23–Feb. 6	Feb. 7–21	Feb. 27–Mar.
Check	No	0.58	0.51	0.51	0.71	1.51	1.35	1.41
Stable manure at 20 tons per ha	No	0.72	0.63	0.85	1.04	1.91	2.08	2.20
Commercial fertilizer at 200 kg	No	1.15	0.82	0.80	1.17	1.70	1.80	1.84
Commercial fertilizer (5–10–5) at:								
500 kg per ha	No	1.09	0.70	1.01	1.08	1.93	1.84	1.78
800 kg per ha	No	1.46	1.18	1.49	1.60	2.51	2.74	2.66
Check	Yes	1.17	1.00	1.23	1.16	2.10	2.77	2.95
Stable manure at 20 tons per ha	Yes	1.10	1.08	1.47	1.31	1.96	2.56	3.00
Commercial fertilizer (5–10–5) at:								
200 kg per ha	Yes	1.35	1.14	1.19	1.40	2.23	2.49	2.88
500 kg per ha	Yes	1.44	1.13	1.43	1.53	2.58	2.97	3.22
800 kg per ha	Yes	1.56	1.34	1.67	1.56	2.55	2.94	3.57

TABLE 1.—*Showing the average 15-day yield of strawberry as affected by mulch and commercial fertilizers*—Continued

Fertilizers applied	Mulched	Yield every 15-day period						
		Mar. 8–22	Mar. 23–Apr. 6	Apr. 7–21	Apr. 22–May 6	May 7–21	May 22–June 5	June 6–20
Check	No	1.63	1.75	1.77	1.59	1.75	0.96	....
Stable manure at 20 tons per ha	No	2.40	2.20	2.05	2.02	2.06	1.04	....
Commercial fertilizer at 200 kg per ha	No	1.93	1.63	1.55	1.88	2.10	1.18	....
Commercial fertilizer (5–10–5) at:								
500 kg per ha	No	2.56	1.96	1.74	1.90	2.36	1.46	....
800 kg per ha	No	2.20	2.12	1.96	2.03	2.06	1.31	....
Check	Yes	3.31	3.02	2.48	2.95	3.90	2.84	0.61
Stable manure at 20 tons per ha	Yes	3.26	2.90	2.40	3.01	3.51	2.88	0.60
Commercial fertilizer (5–10–5) at:								
200 kg per ha	Yes	3.28	3.05	2.51	3.08	3.63	3.20	0.69
500 kg per ha	Yes	3.66	3.37	2.60	3.38	4.04	3.09	0.67
800 kg per ha	Yes	4.05	3.26	2.25	2.94	3.97	3.21	0.85

TABLE 2.—*Showing the effect of fertilizers on strawberry yield in unmulched plots*

Fertilizers applied	Average yield	Increase over check	Significance of difference	Relative yield
	Kilos	*Kilos*		*Per cent*
Check	16.0+1.17	....	....	100
Stable manure at 20 tons per ha	21.2+1.71	5.2+2.07	Slightly significant	133
Commercial fertilizer (5–10–5) at:				
200 kg per ha	19.5+1.51	3.5+1.91	do.	122
500 kg per ha	21.4+1.61	5.4+1.99	do.	134
800 kg per ha	25.3+2.45	9.3+2.72	Significant	158

TABLE 3.—*Showing the effect of fertilizers on the production of mulched strawberries*

Fertilizers applied	Average yield	Increase over check	Significance of difference	Relative yield
	Kilos	*Kilos*	....	*Per cent*
Check	31.5+1.64	....	....	100
Stable manure at 20 tons per ha	30.8+1.67	0.7+2.34	Insignificant	98
Commercial fertilizer (5–10–5) at:				
200 kg per ha	32.1+1.21	0.6+2.04	do.	102
500 kg per ha	35.2+1.32	3.7+2.17	Slightly significant	112
800 kg per ha	45.7+1.33	4.2+2.11	do.	113

TABLE 4.—*Showing the effect of mulching on strawberry production*

Fertilizer applied	Average yield		Increase over unmulched	Significance of difference
	Unmulched	Mulched		
	Kilos	*Kilos*	*Kilos*	
Check	16.0+1.17	31.5+1.64	15.5+2.01	Significant
Stable manure at 20 tons per ha	21.2+1.71	30.8+1.67	9.6+2.39	Do.
Commercial fertilizer (5–10–5) at:				
200 kg per ha	19.5+1.51	32.1+1.21	12.6+1.93	Do.
500 kg per ha	21.4+1.61	35.2+1.42	13.8+2.15	Do.
800 kg per ha	25.3+2.45	35.7+1.33	10.4+2.79	Do.

in unmulched plots, while Table 3 shows the effect of some fertilizers on the yield of mulched strawberry. Table 4 gives the effect of mulching on the yield of strawberries.

In the computation of the data, figures on yield from plots A–7, B–7, C–7, D–7, and E–7 were not included. The stand of the plants in these plots was very poor as compared with the rest of the experimental field. This portion of the field was newly leveled as already stated in the first part of this paper.

DISCUSSION OF RESULTS

EFFECT OF FERTILIZERS ON STAND OF CROP

In connection with field observations, it was noted that the plants in the fertilized plots had a tendency to recover earlier from the effect of transplanting. In the general stand of the crop, however, the fertilized plots showed only a slightly better stand; the plants in the fertilized plots were a little darker green in color than those in the unfertilized plots.

THE BEARING PERIOD OF STRAWBERRIES

The date when the first berries began to mature did not vary very much under the different treatments, but the tendency to mature earlier was in favor of the fertilized plots. The first berries began to ripen as early as the beginning of November, 1931, and the regular harvest was started November 24, 1931. The plants remained in bearing until the middle of June, but beginning with the end of May no harvest could be taken from the unmulched plots; the berries were simply full of soil particles because of rain. The excessive rain in June was the limiting factor in the ripening of fruits.

Figure 2 presents in a graphic was the march in the production of berries under all treatments. It is to be seen in fig. 2 that the maximum production was attained about the end of January and first part of February, 1932. There was a decline in yield in the middle of April, due, perhaps, to the dryness of the soil because of the limited supply of irrigation water. From the time the rains began in the latter part of April until the middle of May, the yield of fruits was good. From this time on, the decline was sharp, mainly because of the heavy rain that was then prevalent.

EFFECT OF FERTILIZER ON YIELD

The summarized effect of the different amounts of fertilizers applied are presented in Tables 2 and 3. As seen in these tables, the fertilized plots gave a higher average production

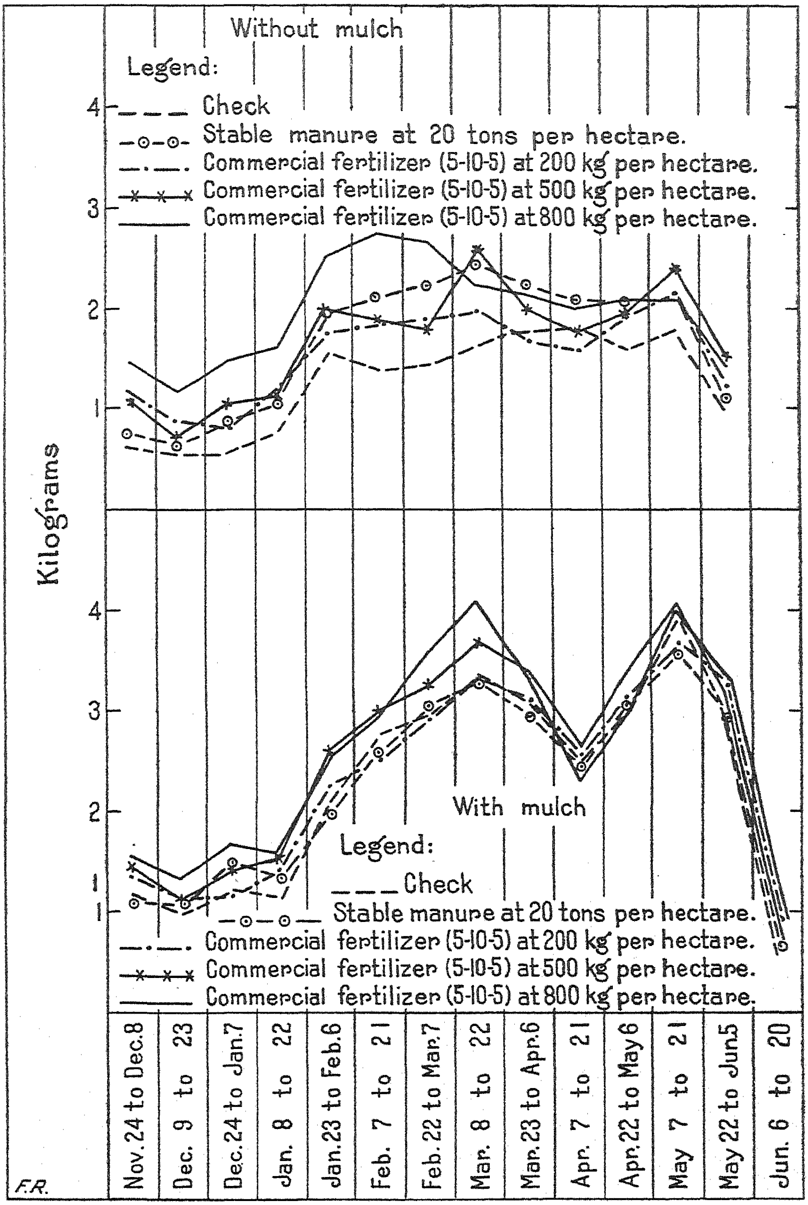

FIG. 2. Graph showing the effect of some fertilizers on the march in yield at every 15-day interval of strawberries grown with and without grass mulch.

than the unfertilized or checked plots. The increase in yield, generally speaking, was more or less proportional to the amount of fertilizers applied. The effect of the fertilizers applied was greater in the unmulched plots than in the mulched ones. The increases in yields over the check in the unmulched plots were 33, 22, 34, and 58 per cent respectively for the stable manure, and the 200-, 500-, and 800-kilo applications per hectare of the commercial fertilizers (5–10–5) (see Table 2). In all cases, except in the 800-kilo rate where the average increase in yield over the check was markedly significant, the increases over the check plots were only slightly significant.

In the mulched plots, the effect of the fertilizers was, at best, but small and this was in the case of the 500-kilo and 800-kilo rates per hectare (see Table 3). Even in these plots, the increases in yield were only 12 and 13 per cent respectively over the check plots.

EFFECT OF MULCH ON STAND OF CROP

The effect of the grass and pine leaves mulch on the stand and appearance of the plants was very much more pronounced than that of the different amounts of fertilizers applied. The mulched plots required two weedings as against the nine weedings and cultivatings required for the unmulched plots. The grass mulch suppressed, to a great extent, the development of weeds, aided in the conservation of the soil moisture, and perhaps regulated the temperature of the soil during cool nights. All these factors must have combined to account for the better stand of the plants.

EFFECT OF MULCH ON YIELD

In Table 4 are presented the summarized data on the effect of mulch on the yield of strawberry. The mulched plots, whether fertilized or unfertilized, gave decidedly better average total yields than the unmulched plots. The total average production per 25 square meters in the unmulched plots were 16.0 + 1.17 + 21.2 + 1.71, 19.5 + 1.51, 21.4 + 1.61, and 25.3 + 2.45 kilograms respectively for the check, and the plots treated with 20 tons of stable manure per hectare, and 200-kilo, 500-kilo, and 800-kilo rate per hectare of the 5–10–5 commercial fertilizer. In the mulched plots, the average total production in the same area with the same treatment were 31.5 + 1.64, 30.8 + 1.67, 32.1 + 1.21, 35.2 + 1.42, and 35.7 + 1.33 kilos respectively. The differences in yields between the mulched and unmulched plots were 15.5 + 2.01 kilos for the check plots, 3.6 + 2.39 kilos

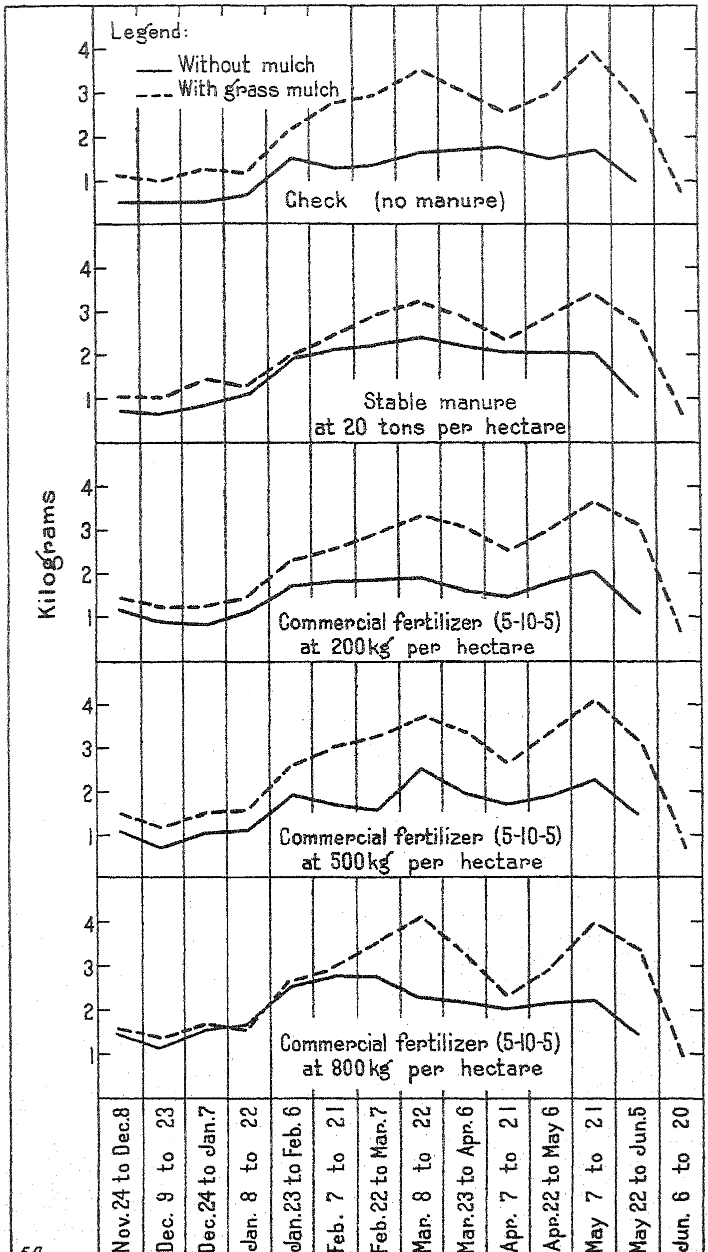

FIG. 3. Graph showing the effect of grass mulch on the yield of strawberries receiving different amounts of a 5-10-5 commercial fertilizer.

for the plots treated with stable manure at the rate of 20 tons per hectare, and 12.6 ± 1.93, 13.8 ± 2.15, and 10.4 ± 2.79 kilos for the plots treated with 200, 500, and 800 kilos per hectare of commercial fertilizers respectively (see Table 4). In all treatments, the increase in average total production was decidedly in favor of the mulched plots. Figure 3 presents in a vivid way the march of production determined at every 15-day period throughout the whole harvesting season between the mulched and the unmulched plots treated with stable manure and commercial fertilizers (5–10–5) applied at different rates.

Putting on dry grass and pine leaves as mulch gave a decidedly bigger yield than using fertilizers, though of course, the combination of mulch and a heavy application of fertilizers brought about the greatest production in the experiment, an average of 35.7 ± 1.33 kilos for a 25-square meter plot, or 14,250 kilos per hectare.

EFFECT OF MULCH ON QUALITY OF FRUITS

The quality of the fruits from the mulched plots was far superior to that from the unmulched plots. In the former, the berries did not come in contact with the ground; this was not so in the latter case. In the mulched plots, berries were picked anytime of the day (early in the morning and just after a rain) and the harvest was free from dirt; such harvest in the unmulched plots were full of soil.

It was further observed that the attack of some fruits rots was decidedly more marked in the unmulched plots. The presence of fruits attacked by fruit rots was more conspicuous when the nights were dewy and the days warm.

No figures were secured as to the cost of putting on dry grass and pine leaves as mulch. However, if the frequent weeding and cultivation and irrigation necessary to maintain the unmulched plots are taken into consideration, the mulching process was certainly cheaper. It may be remarked in passing that at the close of the bearing period of the strawberry, the grass mulch was decayed, ready for plowing under to supply humus in the soil.

SUMMARY OF CONCLUSIONS

1. The effect of stable manure and a complete commercial fertilizer (5–10–5) on the production of strawberries was studied. The effect of grass mulch on strawberry production was also included in the study.

2. In the general stand of the crop, the fertilizers used had only a slight effect; the fertilized plants were slightly darker

green in color than the unfertilized ones. On the other hand, the mulched plots, whether fertilized or not, had a better stand of plants.

3. The fertilized plots, taken in general, gave slightly higher yields than the unfertilized plots. The effect of the fertilizers (stable manure included), was more marked in the unmulched plots. In the mulched plots, the effect of the fertilizers was, at best, slightly significant only, and this was in the case of the 500-kilo and 800-kilo rate per hectare.

4. In all cases (fertilized and unfertilized plots), the effect of grass mulch on the yield of strawberries was decidedly good. A combination of mulching and a heavy application of fertilizers effected the greatest increase in production.

5. The berries picked from the mulched plots were much superior to those from the unmulched plots. The berries from the former set of plots were free from soil and dirt. In the mulched plots the picking could be done very early in the morning as well as just after a rain without any fear of getting the berries all full of dirt.

ILLUSTRATIONS

TEXT FIGURES

THE CHEMICAL COMPOSITION OF CIGARETTES AND CIGARETTE TOBACCO LEAVES OF THE AROMATIC AND NONAROMATIC TYPES

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Very marked differences in the flavor, aroma, and color exist between the locally made Philippine cigarettes and those of the so-called aromatic type of cigarettes represented by well-known American brands. On account of the especially inviting and desirable qualities of the aromatic cigarettes, the great majority of our younger and not a few of the older generation prefer to smoke them. The Philippine importation of aromatic cigarettes has now reached the three and a half million peso mark, while the manufacture of locally produced aromatic cigarettes by foreign firms, using imported aromatic cigarette tobacco leaves either alone or mixed with some of the locally grown cigarette tobacco leaves is becoming quite an industry.

While presumably a great deal of experimental work has been done on the manufacture of aromatic cigarettes, most of these investigations have been carried on by commercial firms, which exercise the greatest care to keep the results of the researches of their scientific staff secret. For this reason, their literary propaganda is conspicuous by the absence of any useful information on the subject.

It therefore becomes important to determine the essential chemical differences in composition between the typical Philippine cigarettes and the imported and locally produced aromatic cigarettes. For blending and other important steps required in the manufacture of aromatic cigarettes, the information to be obtained by such studies is most desirable.

REVIEW OF LITERATURE

The water content of cigarettes as affecting their smoking quality is of great importance. Bogen (1929) states that the moisture of a score of brands of cigarettes as taken from the

package, was found to average 12 per cent. He says further that the inorganic ash content remaining after combustion bears, in general, an inverse relationship to the nicotine content of the tobacco; and that Virginia and Carolina tobaccos contain the highest nicotine content, amounting to 2.5 per cent, West Indian brands 1 per cent, Oriental cigarettes from 1.25 to 1.5 per cent, and the most popular brands from 1.5 to 2.5 per cent. It is probable that the nicotine content of the tobacco is relatively unimportant in relation to its quality. According to Loew (1899) excessive nitrogenous manuring tends to produce a large leaf, of inferior quality containing larger amounts of nicotine. An attempt was made to find the difference between the water, alcohol, ether, and benzene extracts of foreign and Philippine cigarettes by Lava and Etorma (1929) for the purpose of establishing standards of quality. Other investigators conducted chemical analyses of tobacco in relation to its quality. A. Schmuck and Balabuha-Popzowa (1927) arrived at the conclusions that: (*a*) the amount of protein and total nitrogen decrease in the samples of better quality, while the nicotine content and the ash content increase in inferior tobacco; (*b*) the amount of carbohydrates together with that of polyphenols increases in the samples of tobacco of higher quality; (*c*) the ratio of total carbohydrates to the protein is a good index of the quality of tobacco, the higher ratio indicating tobacco of superior quality; and (*d*) that dark colored tobacco contains a greater amount of nicotine, protein, and total nitrogen, and less carbohydrates and phenols than lighter colored tobacco, the latter being therefore superior in quality to the former.

MATERIALS AND METHODS

Five brands of imported cigarettes and eight brands of locally made aromtic cigarettes, eighteen brands of the typical cigarettes, and eighteen varieties of cigarette tobacco leaves were used.

MATERIALS

I. The imported aromatic cigarettes used were as follows: F1, F2, F3, F4, F5.

II. The Philippine-made aromatic cigarettes used were as follows: N1, N2, N3, N4, N5, N6, N7, N8.

III. The Philippine cigarettes used were as follows: N10, N11, N12, N13, N14, N15, N16, N17, N18, N19, N20, N21, N22, N23, N24, N25, N26, N27.

VI. The cigarette tobacco leaves used were as follows:

A. Aromatic (Philippine grown).

1. Virgina Bright.
2. La Union-Sumatra.
3. Sumatra.
4. White Burley.
5. Adcock–Ilagan.
6. Adcock No. 2–La Union.
7. North Carolina Bright Yellow–San Fernando.
8. North Carolina Bright Yellow–Nueva Ecija.
9. Adcock No. 1–Nueva Ecija.
10. Adcock–Alabang.
11. North Carolina Bright Yellow–Ilagan.
12. Adcock No. 2–La Paz, Iloilo.
13. North Carolina Bright Yellow–Alabang.
14. Gold Leaf.
15. Big Warne–Alabang.

B. Native type.

1. Vizcaya–Ilagan.
2. Cebu.
3. Vizcaya Cigar fillers.

METHODS OF ANALYSIS

Water.—A known weight was dried at 10° C. for eight hours, and the loss in weight reported as moisture.

Inorganic matter and sand.—The tobacco was first dried, and a definite weight incinerated over a small Bunsen flame. After all the "volatile carbon" has been expelled the incineration was completed in a muffle furnace heated to a dull red heat, cooled, and the ash moistened with a strong solution of ammonium carbonate, in order to recarbonate the free bases. It was then dried for eighteen hours and weighed.

Sand.—The ash obtained as just explained was treated with hydrochloric acid (1:6), filtered, the residue dried, ignited and weighed. Another method was to treat the ash with concentrated hydrochloric acid, evaporate to dryness, heat to 150°C. for half an hour, treat with dilute hydrochloric acid (1:12), filter, dry the residue, ignite and weigh.

Nicotine: Silicotungstic acid method for the determination of nicotine.—Silicotungstic acid solution: Prepare a 12 per cent solution of the silicotungstic acid having the following formula: $4H_2O.SiO_2, 12WO_3 22H_2O$.

Sodium or potassium hydroxide solution (1:2), and dilute hydrochloric acid (1:4) were also necessary.

Nicotine.—Such a sample was weighed as would contain preferably between 0.1 and 1.0 gram of nicotine (if the sample contained very little nicotine, about 0.1 per cent, that amount must not be increased to the point where it would interfere with the distillation). The tobacco was washed with water into a 500 cc round-bottomed distillation flask, a small amount of paraffin and a few pieces of pumice were added to prevent frothing; and a slight excess of sodium or potassium hydroxide was added, using phenolphthalein as an indicator. It was steamed and distilled rapidly through an efficient condenser and the distillate collected into a flask containing 10 cc of the dilute hydrochloric acid by means of an adapter. When the distillation was proceeding very nicely the distillation flask was heated to reduce the volume of the liquid as far as practicable without jarring or undue separation of insoluble matter. The distillation was continued until the distillate showed no opalescence when treated with a drop of the silicotungstic acid and a drop of the dilute hydrochloric acid. The alkalinity of the residue was confirmed with a small amount of phenolphthalein solution. The distillate was concentrated on a hot plate and the volume made up to 500 cc. If not clear, the solution was filtered. One hundred cc of the filtrate was transferred into a 250 cc beaker and 3 cc of the dilute hydrochloric acid was added. An excess of the silicotungstic acid was added to insure a complete precipitation of the nicotine and the whole was allowed to stay overnight or longer until the precipitate was crystalline in form. The precipitate was filtered using an ashless filter paper, washed with cold dilute hydrochloric acid and ignited in a weighed platinum crucible until all the carbon was removed. Finally it was heated in a Tecler Meker burner for not more than ten minutes. The weight of the residue multiplied by 0.114 gives the weight of the nicotine.

Reducing sugar.—Five grams of the tobacco was weighed and extracted with boiling water for one hour. The beaker was covered with a watch glass and the water lost through evaporation replaced from time to time. The mixture was transferred to a 500 cc volumetric flask, thoroughly cooled, and the volume made up to the mark and then filtered.

Twenty-five cc of each of the $CuSO_4$ and alkaline tartrate solutions (Fehling solution) were transferred into a 500 cc alkali-resistant beaker to which was added 50 cc of the prepared filtrate. The beaker was heated on a piece of asbestos gauze over

a Bunsen burner. The flame of the Bunsen burner was previously regulated so that the boiling began in exactly four minutes. The boiling was continued for 2 minutes. (To regulate the burner for this purpose a preliminary test was made using 50 cc of the reagents and 50 cc of water). The beaker was covered with a watch glass during the heating. After heating the hot solution was immediately filtered through an asbestos mat in a porcelain Gooch crucible, using suction. The precipitate was washed with water at a temperature of 60°C. and the Cu_2O residue dried and weighed.

Sucrose.—Fifty cc of the filtrate from the reducing sugar determination was transferred into a 100 cc sugar flask and 1 cc of 1:1 hydrochloric acid was added. The flask was heated in a water bath to 70°C. and 10 cc of 1:1 hydrochloric acid added. The solution was allowed to air cool for thirty minutes, and was then cooled under running water to room temperature. It was diluted to the mark and filtered. The filtrate was used for the reducing sugar determination. The amount of invert was found with the aid of the Munson and Walker's table. Deduct the percentage of invert sugar obtained before inversion from that obtained after inversion and multiply the difference by 0.95 to obtain the percentage of sucrose.

Starch.—Five grams of the tobacco were weighed and 100 cc of water were added. After one hour's filtering, it was finally washed with 250 cc water. The washed tobacco was transferred with 200 cc water into a 500 cc Florence flask and 20 cc HCl sp. gr. 1.125 added. The mixture was then digested for two and one-half hours using a reflux condenser. After the digestion the residue was filtered into a 500 cc volumetric flask and washed complete, combining the filtrate and washing. The solution was neutralized with 40 per cent sodium hydroxide, cooled and made up to the mark.

It was filtered and the reducing sugar determined. The weight of the reducing sugar multiplied by 0.90 gives the weight of the starch.

Nitrogen.—One gram of sample was weighed and transferred into a 500 cc Kjeldhal flask with 30 to 40 cc concentrated H_2SO_4. Ten grams of salt mixture composed of 10 parts of K_2SO_4 and 0.5 part of $CuSO_4$ were added and the contents of the flask digested until the mixture was colorless or nearly so. After cooling, the contents of the flask were diluted with water and connected with the condenser. After adding an excess of saturated NaOH the mixture was distilled into the standard acid. The

excess of acid was titrated with the standard alkali, using methyl red as indicator. From the amount of acid used calculate the per cent of N_2.

DISCUSSION OF RESULTS

Table 1 contains the analysis of five brands of imported aromatic cigarettes. In the moisture analysis there is a fairly noticeable variation in the cigarette analyzed ranging from 10.53 per cent for F2 to 16.53 per cent for F5. F3 has an ash content of 10.96 per cent as against a maximum of 12.62 per cent obtained from F2. However, the F5 upon analysis gave 1.82 per cent sand and 3.75 per cent for F3. The nitrogen analysis shows a very slight variation, F1 analyzing a minimum of 1.82 per cent as compared to F3 which has a nitrogen content of 2.67 per cent. Again, F3 has a minimum content of nicotine which 1.16 per cent while F5 produces 3.09 per cent. The starch varies from 7.40 per cent obtained from F3 to 9.61 per cent from F5. A marked difference exists in the water soluble reducing sugar. The maximum is 11.10 per cent which is for F4 and a minimum of 3.06 per cent for that of F5. F1 has 0.90 per cent of sucrose as against a maximum of 2.30 per cent for F3.

Table 2 shows the analysis of eight Philippine-made aromatic cigarettes. The differences existing in the moisture analysis of these cigarettes are considerable, ranging from a minimum of 6.63 per cent for N2 to a maximum of 14.72 per cent for N3. The ash content is more or less uniform, the minimum being 9.81 per cent for that of N8 as against 13.85 per cent of F5. The N5 brand has a high sand content of 4.04 per cent, compared with 1.51 per cent for N8, giving an average of 2.45 per cent. Excepting N1 and N2, all the other brands of cigarettes have a more or less uniform nitrogen content, the average on the whole being 2.08 per cent. The nicotine content of N8 is rather distinct, it being 2.86 per cent as compared to 1.36 per cent for N3 or with the average of 2.16. Moreover, N2 has a starch content of 10.13 per cent against N8 which is 6.71 per cent. For the water soluble reducing sugar the N3 was found to contain 12.86 per cent, this being the maximum and the N7 with 5.25 per cent as the minimum or with the average of 8.68 per cent. As to the sucrose content N2 and N4 were found to contain the same amounts with 1.21 per cent as compared to N3 which is as low as 0.33 per cent.

Table 3 shows the analysis of typical made cigarettes. Scrutiny of the table shows that the moisture content of N12 and N13

are 14.24 and 14.02 per cent, respectively. The N18, N22, N24, N27 have a uniform content of slightly over 12 per cent. All the rest have a very marked uniformity or moisture content. The trend of the ash content of all cigarettes analyzed assumed parallel results from 14.36 per cent of that of N10. N19 has a significantly low ash content of 0.42 per cent as compared with the 3.28 per cent of N24. Excepting N11, which has a nitrogen content of 0.44 per cent, all the rest range from 1.51 of N20 and N12 to 2.91 per cent. The N10 was found to contain the minimum amount of nicotine of 0.62 per cent as against 2.02 of N27. The N26 contains about twice as much starch with 13.72 per cent as any of the other native cigarettes analyzed. The water soluble reducing sugar content varies from 0.16 of Katubusan to 3.50 per cent to that of N27. The N16 had only a trace of the water soluble reducing sugars.

Table 4 gives the results on the analysis of 16 important aromatic cigarette tobacco leaves. Parallel results are seen in figures of the moisture content of imported cigarettes, excepting La Union–Sumatra and Sumatra, which are 9.59 and 6.56 per cent, respectively. The ash content varies from 7.05 per cent for Adcock–Ilagan to 15.49 for Sumatra. Big Warne–Alabang analyses 0.38 per cent sand as against 5.28 per cent for Adcock No. 2–La Paz, Iloilo to 2.86 of that of La Union–Sumatra. The nicotine analysis varies from 0.22 per cent for Adcock–Ilagan to as high as 5.98 per cent for White Burley. The N. C. B. Y.–Alabang variety has an exceptionally high starch content of 13.32 per cent as against N. C. B. Y.–Nueva Ecija, which is 2.67 per cent. For the water soluble reducing sugar the N. C. B. Y.–San Fernando analyzed 1.83 per cent as against 18.20 for Adcock–Ilagan.

Table 5 shows the analysis of three native cigarette tobacco leaves. The moisture content of the three varieties analyzed has a maximum in the Vizcaya of 13.37 per cent and a minimum of 9.59 per cent in the Cebu. The moisture of the Vizcaya Ilagan, which is 11.80 per cent, averaged about 11.59 per cent. The ash content is more or less uniform. The Vizcaya (cigar filler) variety analyses 1.45 per cent sand as against 5.39 per cent of Cebu. The nitrogen content of the Vizcaya–Ilagan, Isabela; and Cebu are nearly uniform, with 3.93 and 3.45 per cent respectively. The Vizcaya (cigar filler) has only 1.84 per cent. The nicotine of Vizcaya (cigar filler) is rather low as against Cebu, which is 3.03 per cent. Cebu has a maximum starch content of 13.36 while the Vizcaya (cigar filler) has 8.35.

Only the Vizcaya–Ilagan, Isabela variety contains water soluble reducing sugar of 4.40 per cent.

Table 6 gives the average of the analysis of the different makes of cigarettes and cigarette tobacco leaves. Between the Philippine and the imported aromatic cigarettes there are wide differences in some analysis, and small difference in others. A very great difference is most noticeable in the water soluble reducing sugar. The native cigarettes analyzed on the average 0.86 per cent while the imported aromatic cigarettes gave as high as 6.78 per cent or a difference of 5.92 per cent. The result of the nicotine analysis is very interesting. The native cigarette, due to its deep brown color, and poor aroma would be expected to yield more nicotine than the aromatic tobacco used in the imported cigarettes. However, the contrary proved true. The nicotine content of the Philippine cigarettes on the average is only 1.12 per cent as compared with that of the imported cigarettes, which is 2.27 per cent. The ash analysis for both cigarettes shows also a very marked difference. While the imported has an ash content of 11.78 per cent the Philippine cigarettes showed 16.70 per cent. The reverse is true for moisture. The imported aromatic has 13.93 per cent, which is 2.15 per cent more than that obtained from Philippine cigarettes. The starch shows a moderate variation. The imported cigarette yielded 8.12 per cent and the Philippine cigarette 6.41 per cent. A small difference exists in the nitrogen. The imported aromatic cigarette gave 2.07 per cent, against 2.41 per cent obtanied from the Philippine cigarettes. The imported cigarettes analyzed 2.58 per cent while the Philippine cigarettes gave 1.23 per cent.

Aside from the moisture analysis the differences in composition between the typical and the Philippine-made aromatic cigarettes is parallel to that existing between the typical and the imported aromatic cigarettes. The Philippine cigarettes have 11.78 per cent, which is 0.03 per cent higher than that obtained from the imported aromatic cigarettes. The Philippine cigarettes have a fairly high percentage of ash, 16.70, as compared with 11.85 per cent obtained from Philippine-made aromatic cigarettes. Moreover, the Philippine-made aromatic cigarettes analyzed 2.45 per cent for sand which is 1.22 per cent more than the native cigarettes. The nitrogen, on the other hand, does not show much difference, being 2.41 per cent for Philippine cigarettes and 2.08 for Philippine-made aromatic cigarettes. Again, the nicotine of the Philippine-made aromatic is higher, being

2.16 per cent as against 1.12 per cent for Philippine cigarettes. Not a very pronounced difference exists between the starch analyses. The Philippine-made aromatic cigarettes gives 8.03 which is 1.62 per cent more than that obtained from the Philippine cigarettes. A very striking difference is manifested in the water soluble reducing sugar; a fairly high content of 8.68 per cent from the Philippine-made aromatic cigarettes as against the significantly low figure of 0.86 from the native cigarettes. The Philippine cigarettes did not give any sucrose upon analysis, while the Philippine-made aromatic cigarettes have 0.79 per cent.

SUMMARY

The trend of analysis on the imported aromatic and Philippine aromatic cigarettes has a very distinct parallelism, the differences being small in the majority of the analyses. The Philippine non-aromatic cigarettes show remarkably distinct differences in some of the constituents of the results obtained from the imported aromatic and the Philippine-made aromatic, cigarettes. In several analyses the imported aromatic cigarette tobacco leaves showed marked differences from the native cigarette tobacco leaves.

TABLE 1.—*Analysis of imported aromatic cigarettes*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble sugars	
Accession No.	Name							Reducing	Sucrose
Ac-32-11...	F 1......	13.63	12.26	2.96	1.82	2.20	8.31	6.32	0.90
Ac-32-13...	F 2......	10.53	12.62	2.65	1.49	2.11	7.44	8.27	2.07
Ac-32-34...	F 3......	13.48	10.96	3.75	2.67	1.16	7.40	7.14	2.30
Ac-32-65...	F 4......	15.72	11.57	2.61	2.18	2.77	7.85	11.10	2.11
Ac-32-67...	F 5......	16.53	11.41	1.81	2.17	3.09	9.61	3.06	0.29
Average....	....	13.98	11.78	2.58	2.07	2.27	8.12	6.78	1.35

TABLE 2.—*Analysis of Philippine-made aromatic cigarettes*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble sugars	
Accession No.	Name							Reducing	Sucrose
Ac-32-12...	N 1......	11.93	11.07	2.94	1.51	2.72	7.29	6.41	1.21
Ac-32-14...	N 2......	6.63	11.30	2.72	1.89	2.74	10.13	6.96	1.07
Ac-32-28...	N 3......	14.72	12.86	2.00	2.04	1.36	8.22	12.86	0.33
Ac-32-29...	N 4......	9.84	11.27	2.02	2.20	2.08	....	9.32	1.21
Ac-32-30...	N 5......	12.30	12.23	4.04	2.10	1.92	....	8.20	0.13
Ac-32-64...	N 6. / N 7.	14.66	12.42	2.47	2.61	1.74	8.41	5.25	....
Ac-32-66...	N 8......	12.52	9.81	1.51	2.17	2.86	6.71	10.35	0.78
Average....	....	11.75	11.85	2.45	2.08	2.16	8.03	8.68	0.79

TABLE 3.—*Analysis of typical cigarettes*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble reducing sugar
Accession No.	Name							
Ac-32-35	N 10	10.70	19.14	1.16	2.52	0.62	6.13	0.28
Ac-32-36	N 11	10.08	19.13	0.85	0.44	0.82	6.19	2.55
Ac-32-37	N 12	14.24	14.38	2.06	2.91	0.81	5.71	0.18
Ac-32-38	N 13	14.02	16.60	2.78	2.48	0.87	5.08	0.16
Ac-32-39	N 14	9.12	18.22	1.13	2.76	0.60	5.14	0.57
Ac-32-40	N 15	10.80	17.72	0.65	2.69	1.26	6.58	0.55
Ac-32-41	N 16	10.25	18.02	0.67	2.62	0.59	6.82	Trace
Ac-32-42	N 17	11.36	17.30	0.60	2.40	0.91	6.39	0.96
Ac-32-43	N 18	13.18	14.88	2.02	2.89	1.34	5.28	0.13
Ac-32-44	N 19	12.20	15.68	0.42	1.58	1.34	5.82	1.43
Ac-32-45	N 20	11.45	15.95	0.53	1.51	1.46	6.11	1.11
Ac-32-46	N 21	11.09	16.82	0.94	2.51	1.23	6.11	0.92
Ac-32-47	N 22	13.74	14.28	1.49	2.70	1.52	6.30	0.28
Ac-32-48	N 23	10.69	17.85	0.78	2.67	0.62	5.96	1.09
Ac-32-49	N 24	13.04	18.04	3.28	2.28	1.53	6.26	0.47
Ac-32-50	N 25	11.72	15.03	0.93	2.90	1.27	5.75	0.93
Ac-32-51	N 26	11.25	15.74	1.04	2.95	1.36	13.72	0.35
Ac-32-52	N 27	13.09	15.76	0.85	2.53	2.02	5.97	3.50
Average		11.78	16.70	1.23	2.41	1.12	6.41	0.66

TABLE 4.—*Analysis of imported aromatic cigarette tobacco leaves*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble reducing sugar
Accession No.	Name							
Ac-32- 8	Virginia Bright	17.23	12.21	3.55	2.01	3.00	....	8.38
Ac-32- 9	La Union Sumatra	9.59	15.16	2.25	2.86	....	....	4.06
Ac-32-10	Sumatra	6.56	15.49	5.28	2.60	1.60	....	6.87
Ac-32-27	White Burley	12.43	11.14	4.07	2.78	5.98	6.35	10.08
Ac-32-53	Adcock-Ilagan	18.59	7.05	0.75	1.85	0.22	....	18.20
Ac-32-54	Adcock No. 2-La Union	12.99	15.28	3.12	2.72	0.51	3.93	2.56
Ac-32-55	N. C. B. Y.-San Fernando	13.19	15.15	3.81	2.51	1.17	3.28	1.83
Ac-32-56	N. C. B. Y.-Nueva Ecija	11.84	13.82	4.02	2.22	1.69	2.67	14.09
Ac-32-57	Adcock No. 1-Nueva Ecija	12.12	12.10	4.42	1.48	0.85	8.69	9.06
Ac-32-58	Adcock-Alabang	15.57	12.82	8.72	2.27	1.12	5.77	7.35
Ac-32-59	N. C. B. Y.-Ilagan, Isabela	16.00	8.78	0.94	1.92	1.34	2.27	12.25
Ac-32-60	Adcock No. 2-La Paz, Iloilo	12.16	13.07	1.41	1.38	0.26	9.34	13.98
Ac-32-61	N. C. B. Y.-Alabang	12.93	9.78	0.96	1.72	1.46	13.32	9.32
Ac-32-69	Gold Leaf	17.87	9.19	0.66	....	1.85	4.89	3.54
Ac-32-70	N. C. B. Y.-Alabang	15.93	10.44	0.65	....	1.78	6.40	3.20
Ac-32-71	Big Warne-Alabang	16.53	9.75	8.38	....	1.93	....	....
Average		13.84	11.95	2.31	1.77	1.65	6.63	8.32

TABLE 5.—*Analysis of native cigarette tobacco leaves*

Samples		Moisture	Ash	Sand	Nitrogen	Nicotine	Starch	Water-soluble reducing sugar
Accession No.	Name							
Ac-32-62	Vizcaya-Ilagan, Isabela	11.80	16.04	2.29	3.93	1.12	11.49	4.40
Ac-32-63	Cebu	9.59	17.51	5.39	3.43	3.01	13.36	....
Ac-32-68	Vizcaya (cigar filler)	13.37	17.91	1.45	1.84	0.57	8.35	....
Average		11.59	17.15	3.04	3.07	1.57	11.07	1.47

TABLE 6.—*Summary table*

Analysis	Imported aromatic cigarettes	Philippine aromatic cigarettes	Philippine non-aromatic cigarettes	Cigarette tobacco	
				Imported	Native
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Moisture	13.93	11.75	11.78	13.84	11.59
Ash	11.78	11.85	16.70	11.95	17.15
Sand	2.58	2.45	1.23	2.31	3.04
Nitrogen	2.07	2.08	2.41	1.77	3.07
Nicotine	2.27	2.16	1.12	1.65	1.57
Starch	8.12	8.03	8.41	6.63	11.07
Water reducing sugar	6.78	8.68	0.86	8.32	1.47
Sucrose	1.35	0.79	....	....	....

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OBSERVATIONS ON TWO FORMS OF STERILITY IN RICE

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SEVEN PLATES AND TWO TEXT FIGURES

Sterility in rice means the failure to produce grains. In a broad sense it implies the occurrence of undeveloped or abnormally small flowers, or the appearance of empty or imperfect grains in the panicle, either partial or complete, brought about by unfavorable weather or environmental conditions, defective reproductive organs, genetic incompatibility, parasitic fungi, insect pests, or other factors. A combination of two or more of these factors, however, may at times be responsible for the incidence of sterility.

Sterility is one of the causes of poor rice yields in the Philippines, and knowledge concerning it would be of practical value to the rice grower. In the present paper we place on record the extent of damage resulting from the two conditions of rice sterility here described. On kind of sterility has been often found in rice fields, occurring naturally year after year in more or less varying degrees of severity, but apparently has attracted little or no attention. The other kind is less perceptible and is brought about by the cross-fertilization of divergent types, or of parents possessing incompatible genetic qualities, or it

may be inherited from forms producing abortive spikelets in more or less varying degree, and may arise spontaneously and remain true to type. For convenience we might call the first "white sterility" and the second "cross sterility." Notes and field observations are also given.

HISTORY, DISTRIBUTION, AND ECONOMIC IMPORTANCE

Undoubtedly sterility in rice occurred in the early history of rice cultivation in this country. In the year 1912, Borja noticed among several varieties in plot culture in the Alabang Rice Experiment Station, Rizal Province, Luzon, one which exhibited a white, turfy appearance at the terminal portion of some panicles in a considerable number of plants. The characteristic defect of terminal glumes has reoccurred in a more or less varying degree of severity in succeeding generations and is seemingly a true hereditary character.

The earliest official communications regarding the occurrence of rice white sterility were addressed by Mr. Hilary P. Clapp to the Bureau of Science and were dated June 16 and 26, 1920. Mr. Clapp then stated that the trouble, as it appeared in the Mountain Province, was of a very serious nature, affecting considerably the flowering of rice in and around Trinidad Valley, which has an altitude of about 4,000 feet above sea level. It was so severe at that time, the informant further stated, that it was quite impossible to find a sound panicle in the fields! He allayed the fears of the farmers in that region by estimating a probable loss of 25 per cent of the rice crop. For lack of a better term, the trouble was provisionally referred to as the "Trinidad disease," by H. A. Lee, then mycologist of the Bureau of Science.

In a brief personal inquiry and observation made by Reyes about the end of June, 1920, white sterility was found uniformly distributed and was very noticeable in the rice fields, and information was further obtained from Mr. J. A. Wright and Mr. Flores, principal and teacher, respectively, of the Trinidad Farm School, to the effect that it was the first appearance of the "disease" in Trinidad Valley, although the natives who had been growing rice there claimed to had observed it in previous years. The latter information seems to the writers authentic because the farm school had then been growing rice for only two seasons, and the seeds were believed to have been obtained originally from Bontoc where rice has long been cultivated. As

no counts were made of sterile flowers in any population, the actual amount of damage was not known. The partial sterility, however, shown in the accompanying plates, taken from representative specimens, gives some idea of the proportion of sterile spikelets. In the Twentieth Annual Report of the Bureau of Science, for the year ending December 31, 1921, a serious "disease" of rice causing sterile heads was reported as occurring in the Mountain Province, which most likely refers to the same defect. In 1932, the loss from this sterile condition in the lowlands at Alabang, Rizal Province, was carefully estimated from affected varieties grown in plots under the same conditions, and it varied on an average of from 14.43 to 24.40 per cent.

In past years, a similar form of sterility was observed in Rizal, Cavite, Tarlac, and other provinces, and reports of its occurrence were received from Cotabato Province. In none of these regions, however, was the injury so great as that found in the terraces and plains of the high altitudes. In India, Bhide(1) reported, in 1922, the incidence of this form of sterility in rice flowers, and later Ramiah,(5) in 1931. In Coimbatore, 2 to 40 per cent sterility had been observed by Ramiah in pure lines.

Regarding the presence of sterility in rice, Terao(8) in 1921, Suzuta and Suematu,(7) and Ishikawa,(2) in 1927, reported the occurrence in Japan of semisterility in rice plants in the ratio of 1 : 1. Nagai(4) in 1926, also gave an account of partial sterility in rice in that country, resulting in a 1 : 1 ratio. In the experiments of Ishikawa,(2) it was found that partially sterile plants produced fertile and sterile offspring in the ratio of 7: 1, but in semisterile plants, the split was in the ratio of 1: 1.

Sterility in three natural hybrids has been observed in the Alabang Rice Experiment Station by Torres(9) in the Gopher variety, and on artificial hybrids of Storm Proof ♀ x Apostol ♂, and Baladong ♀ x Apostol ♂. These hybrids were studied to determine whether the sterility was inherited.

In the 1931-1932 rice season, the incidences of sterility were also observed at the Alabang Rice Experiment Station, Rizal Province, in certain artificial crosses made to produce desirable new types. The most notable of these were between varieties having marked contrasting characters, as between Ramay ♀[1] x Inadhica ♂ and Elon-elon ♀[2] x Inadhica ♂ (Plate 5), which

[1] A variety introduced from French Indo-China.

[2] Believed to be a Chinese variety, but named after the importer.

showed in actual counts of filled and empty spikelets of panicles selected at random from ten plants in F_3 and F_2 generations, a range of from 8.8 to 31.5 per cent and 20.3 to 60.3 per cent, or an average of 16.5 per cent and 30.9 per cent, respectively. It should be remarked that Inadhica, one of the parent varieties, normally exhibits a large percentage of sterility, amounting to 25 per cent in round numbers. There are other varieties showing similar characteristics, which suggests that they are probably of hybrid origin.

According to Bhide,(1) an artificial hybrid between a starchy variety called "botka" and "black" rice, a glutinous type, gave complete sterility in F_1, which exhibited an unusually heavy vegetative growth. In a cross between pure lines, Ramiah(5) observed as much as 95 per cent sterility, but this he was inclined to think a mutant. The same author states that sterility was markedly manifest in hybrids produced by crossing varieties having wide varietal characteristics, such as length of maturity, tillering habit and size of grains, and that in parents where practically no sterility has been observed, 4 to 56 per cent sterility resulted in the F_2 generations. As cited by this author(5) Jones, in the United States, also made reference to this kind of sterility in the first generation hybrids, and in progenies resulting by crossing Chinese and Japanese rice varieties. In the investigation of Kato et al.(3) in Japan, it was demonstrated that crosses of varieties of similar morphological characters gave high fertility, amounting to 68.7 per cent in their F_1 plants, whereas the hybrids of crosses between different types gave a low fertility of about 14 per cent. The corresponding figures for the F_2 plants are 80.9 and 26.2 per cent.

DESCRIPTIONS OF RICE STERILITY

The first kind of sterility in the inflorescence of rice for which the name "white sterility" is proposed by the writers, is characterized by the presence usually at the terminal portions of the panicle (Plates 1 and 3) of abnormally small, empty, white spikelets occurring in groups, but these may also be found in or about the middle or the base (Plates 1 and 4), or anywhere else in the panicle (Plate 2), presenting a very marked contrast with the normal flowers. As the normal grains ripen these sterile rudimentary spikelets shrivel up and drop off, leaving sometimes traces of the barren stalks on the panicle (Plate 4, fig. 2). The number of glumes affected in a panicle varies. This kind of sterility should not be confused with the pseudo-

sterility caused by stem borers (larvæ of a small moth, *Schoenobius incertellus* Walker), or by a small, brown rice grasshopper, a species of the genus *Catantops* [3], which can be readily distinguished by the "white heads" ("uban" in Tagalog), so called on account of the stiff white appearance that the whole panicle exhibits when all the flowers glumes are empty and closely compacted to the rachis.

Cross sterility, on the other hand, is readily recognized by the occurrence in an otherwise normal panicle of single empty flower glumes or abortive spikelets, scattered more or less uniformly among well-developed grains. In the first stages of development they are not easily detected, but they become obviously manifest as the panicle matures (Plates 5, 6, and 7). The fertile flowers assume their normal color gradually as they ripen, while the sterile ones remain greenish for some time and then change to a pale straw color. In dark-colored hybrids or in those whose glumes have shades deviating from the straw color on maturity, there is a clearer distinction between sterile and fertile grains (Plate 5).

CAUSES OF RICE STERILITY

The white sterility herein described has been attributed to a variety of causes. Many purely hypothetical conjectures have been made some of which merit serious consideration. Among peasants and hill tribes the cause is ascribed to certain superstitions. The most reasonable beliefs revealed in conferences held with rice planters and others familiar with rice growing are that sterility is due to unfavorable weather conditions or to physiological disturbance in the rice plant, or that it is a morphological defect in the flower resulting in nonfertilization. Others think that it is due to the attack of some fungous disease or insect pest. It is not, however, the purpose of this article to prove or disprove all these theories.

Fresh specimens examined both macroscopically and microscopically disclosed nothing in their general appearance, roots, stems, and all that would lead to any probable pathological or entomological diagnosis. The affection does not spread or extend to the healthy unaffected parts of the panicles, so that we can be sure that it is nonparasitic and not infectious. Isolations made from freshly collected specimens in the early stages, in an effort to grow any possible fungi or bacteria which might be present, have revealed the absence of any one organism which

[3] Identified by Mr. F. Q. Otanes of the Bureau of Plant Industry.

might be the cause. In a very few cases bacteria were obtained in such a small proportion that we were led to believe they were only chance infections or contaminations. In other words no evidence of fungous disease was found and no insect pest was associated with it, so that the theory relative to a fungous disease or an insect pest seems out of the question in so far as our investigation showed.

Weather relations.—Although there is no direct evidence, there is every reason to believe that the trouble is due at least partly to some unfavorable weather or climatic conditions. Rain occurring at the critical period of pollination followed by hot sunshine is responsible for the occurrence of sterility. This weather condition often obtains in October, coincident with the flowering of early varieties of rice in central Luzon, Panay Island, and elsewhere.

Arrested development may be also due to high winds. November 24, 1928, an extraordinary typhoon occurred which hit Alabang, Rizal Province, at the time certain late-maturing varieties, normally fertile, were in the boot stage. As a result the plants lodged and the panicles were partially sterile.

Salmon(6) attributed the low yield of durum wheats to the prevalence of an unusually dry, hot spell during the flowering period in the Great Plains, United States, in 1910 and 1911. To him is also credited the statement that low relative humidity rather than high dryness of air is the main controlling factor. Ramiah(5) stated that the opening of the rice glumes and the dehiscence of the anthers are greatly influenced by the air temperature and moisture prevailing. So that when blooming takes place during high and dry atmospheric temperature, the anther sacs shrink and do not dehisce. A similar phenomenon has been repeatedly observed at the Alabang Rice Experiment Station in panicles bagged with paraffin paper for selfing or other purposes, in which the moisture and temperature conditions created within the bag generally proved detrimental to the anthers and consequently to successful fertilization.

The planting of rice in the wrong season is an outstanding example of the deleterious effects of unfavorable weather on grain yield. Ramiah(5) found in tests on the incidence of sterility at different times of sowing, that excessive rainfall during the flowering period, or very dry soil at the time of greatest transpiration, is conducive to sterility. In support of this argument, we might quote what Ramiah has to say: "It is

recognized that every variety of rice has an optimum season, and growing it in the wrong season results in poor yield, one of the contributing causes for such low yields being the occurrence of sterility."

Weather fluctuations are chiefly responsible for the planting of rice in off-seasons in this country. Failure of rain to come at the time the fields are due for plowing causes delay in transplanting, as also when drought comes and dries the fields before the crop can be put in. The result of delayed transplanting is manifested in stunted growth and it may be stated that infertility here is largely a consequence of the weakened constitution of the plants.

In the case of failures of flowers to develop normally due to insufficient moisture in the soil, as when a protracted drought affecting unirrigated crops occurs, we see a general withering, both of vegetative and reproductive parts. A case in point is the Macan China rice grown in Guimba, Nueva Ecija Province, in 1927. In November, that year, some days after the plants had headed out, a drought prevailed, and the crop presented erect panicles with the characteristic pale, greenish white color. Upon examination the glumes were found to be partly open, containing the undeveloped pistil in a semi-dry state.

The condition of heading where only part of the panicles emerges from the leaf sheath is another form of arrested reproductive growth partly due to drought. Here fertilization, if any, succeeds only to a limited extent, so that a more or less high percentage of sterility is evident in such panicles. The variety Inantipolo, for instance, is highly susceptible to this form of partial sterility on account of its peculiar habit of heading out unevenly and at a slow rate. The rapidity at which the plants can send the flower structure out is known to differ with different varieties. Pure line plants selected for uniformity of heading exhibit it to the highest degree, while abortive heading, extremely variable, is common to all exotic unacclimatized varieties.

The foregoing instances include the effects of the physical factors which have come to our notice, although undoubtedly there are some more. It can be easily understood that when drought exerts its effect after fertilization has taken place, the manifestation is quite distinct from white sterility, in that while the pistil development is arrested the floral structure is complete and has assumed its normal color up to the time of withering.

In a typical case of white sterility the glumes are papery and lacking the cilicious nature of the flowers that have attained a certain development, indicating an early formation of the "white flowers" at heading or while the panicle is within the leaf sheath. Elsewhere is described a sort of atrophy in which normal flowers and undersized ones were found in a panicle in the boot stage.

Physiological and morphological relations.—The findings of Ramiah(5) throw some light on this question of rice sterility, in that abortion or arrested development takes place in the anther sacs and the ovaries, and that it has been found to be a varietal character frequently associated with a certain size and arrangement of grains, such as small grains and compact grains in the panicle. The same author asserts that it is a varietal "Mendelian character, simple and recessive to the normal spikelet," and claims that the incidence of terminal sterility can be augmented by excessive applications of manure in the affected rice fields. Too much soil fertility causes the plants to lodge even at the time of flowering, due to rank vegetative growth, resulting in the production of sterile spikelets. The writers are inclined to believe that the failure of fertilization may result from exposure, because the top grains, where pollination usually takes place first, are generally the ones affected. Some cases of sterility, however, were found when the panicles were yet inclosed in the boot, indicating that retarded emergence affects the fertility of the flowers (text fig. 1, *a*, and Plate 4, fig. 1) as already mentioned. Comparing this rice flower affection observed in the Philippines with that occurring in India as reported by Ramiah(5) it is safe to infer that they are closely similar, if not identical.

Morphologically abnormal pollen (text fig. 2, *a* to *c* and *e*) is said to be a common cause of sterility in rice. Also, when stigmas do not develop at the same time as the anthers, they remain inside the glumes and when the flower glumes close they miss the reception of the pollen. Sterility may be due sometimes to defective stigmas (text fig. 1, *b*) and ovaries or to an abnormal arrangement of the flower structure. Bhide(1) reported that he had found in a variant collapsed and nonviable pollen grains which had little or no contents and that the pollen and anthers did not show their natural yellow color, while although the ovary was apparently normal, no grain developed. Suzuta and Suematu(7) claimed to have often seen in semisterile

paddy rice plants embryoless seeds, or water taking the place of the endosperm. The findings of Bhide we have confirmed in the Philippines (text fig. 2), and they revealed the following facts:

All examinations of sterile florets were made from fresh panicles of Guinangang Str. 1, which had not yet emerged from the boot. Those found at the tips were generally much smaller than those found at the lower laterals and were all white, becoming slightly twisted or curved on exposure to dry atmosphere. Some defective florets occurring at the base of panicles were also white, but the apical and basal portions of the inner glumes had a greenish tint. Sometimes the nerves were also greenish. They contained the essential organs (text fig. 1, *b*) of normal flowers, but the stigmas seemed to be less feathery or not well developed and not freely exposed. Anthers having a pale yellow color obtained from fifteen chartaceous flowers when burst showed, on microscopic examination, pollen grains having little or no contents (text fig. 2, *a*), and fewer in number than those found in the normal anthers; while those from twenty-

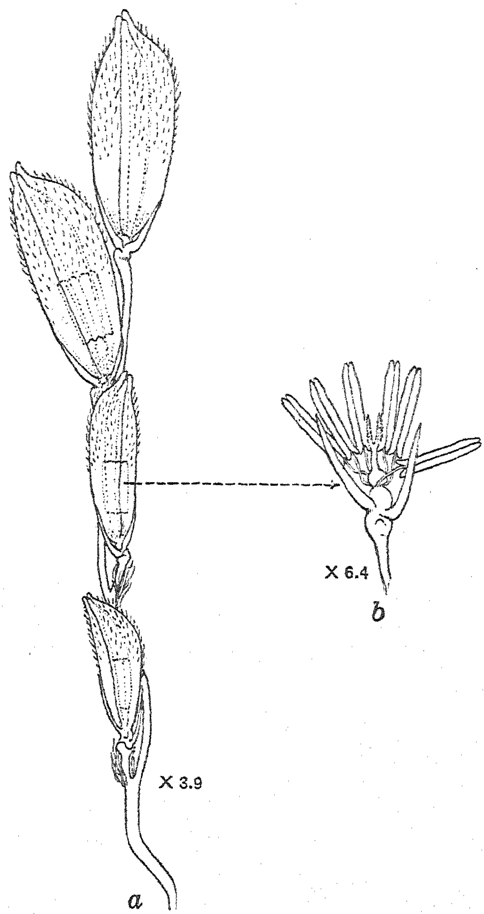

FIG. 1. *a*, Portion of a rice spike of Guinangang Str. 1, obtained from a panicle still within the barrel, to show the comparative sizes of normal and sterile flowers, approximately x 3.9. *b*, Reproductive organs obtained from the third flower shown in *a*, possessing all the essential organs but having somewhat less feathery or poorly developed stigmas and the filaments of the abortive stamens not fully extended, about × 6.4.

eight dimunitive white flowers having white or slightly yellowish anthers contained no pollen at all. The proportion of undeveloped flowers having pollen to those without any pollen (usually from white anthers) was 6: 25.

The pollen dislodged from sterile flowers is more or less hyaline, having a germ pore (text fig. 2, *a-c* and *e-f*) or rarely two in each grain, and they appear to be empty or without the granular, yellowish contents found in normal pollen grains (text

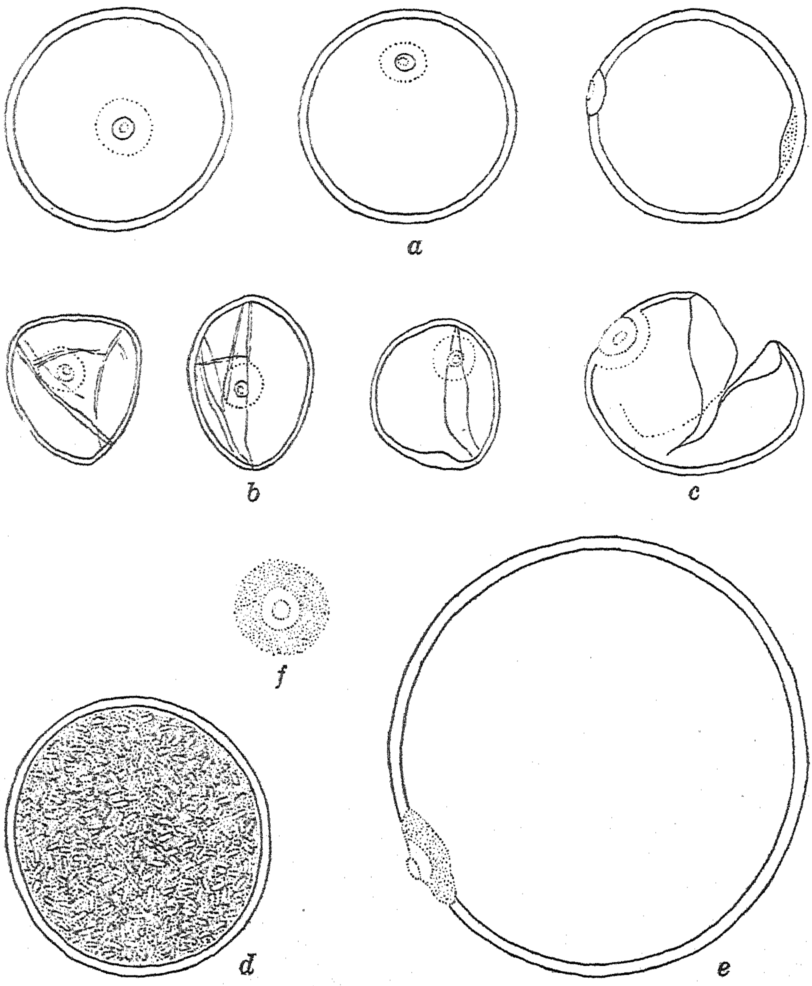

FIG. 2. Imperfect pollen grains obtained from sterile florets of the same variety, drawn with a camera lucida to show morphological structures: *a*, Fresh pollen grains without contents; *b*, shriveled pollen grains assuming various shapes; *c*, a burst pollen grain, × 653; *d*, normal pollen grain to show the difference, × 653; *e*, a highly magnified sterile pollen grain without contents, showing the germ pore at the periphery, × 1,300; *f*, a front view of the germ pore × 1,300.

fig. 2, *d*) ; hence, nonfunctional. These imperfect pollen grains are approximately of the same shape (text fig. 2, *a*), fewer in number than the grains in normal flowers, and are undersized, some being very small. They easily collapse (text fig. 2, *b*) for lack of the necessary contents and probably due to rapid shrinkage, or else they are weakly developed. However, pollen grains with scanty content were few in number. Pollen from sterile florets does not germinate, as found by tests made even with the use of different media.

For purposes of comparison, normal pollen grains were also studied. They were variable in size but fairly round and regular in shape. Under the microscope they exhibited a granular substance having a yellowish tint and were rather thick walled (text fig. 2, *d*). When they burst the granular contents, which were elongated bodies measuring 1.42 μ by 4.28 μ, came out. There was at least one germ pore in each pollen grain, made visible when the contents are forced out, measuring about 3.99 μ in diameter on the average. Water mounts of normal fresh pollen grains measure from 36.05 microns to 57.0 microns, while the grains obtained from undeveloped flowers are from 34.20 microns to 55.57 microns in diameter.

Genetic relations.—The second form of sterility discussed here, or cross sterility, is believed to be a hereditary complex resulting from the blending of two incompatible or widely divergent parental qualities, and by crossing varieties one or both of which possess these undesirable qualities. Kato and his collaborators(3) found that the formation of pollen of F_1 plants derived from the same parental type was nearly perfect, but the pollen of hybrids between different types was quite imperfect. The proportion of imperfect pollen grains was 55.7 per cent in the minimum, 75.7 per cent in the maximum, and 66.1 per cent on the average. This abnormality is attributed to the "disharmony of the chromosomes," or to the abnormal development of the pollen following the tetrad formation of the pollen mother cell. By examining the degree of fertility in the hybrid plants and subjecting them to a serodiagnostic test for corroboration, they were able to determine the sexual affinity of the cultivated varieties of rice in Japan and show that morphologically distinct varieties are distantly related in descent. In certain pedigreed varieties, which are also probably of hybrid origin, we have observed a similar defect. The sterile glumes, according to Ramiah(5) contain all the essential organs normally developed, a

fact that has been corroborated by our findings in the Philippines. Field observations indicate that many flowers do not open at all and, on examination, the anthers do not dehisce but simply wither within the glumes. Stigmas are in many cases also found withered.

EVIDENCES OF WHITE STERILITY

Field observations conducted in Trinidad Valley, Mountain Province, and in Rizal Province have shown that the degree of white sterility differs among the varieties there. Their reaction was found as follows: In the Mountain Province, Maletecan, an awned variety, was very susceptible as, to some extent, was Baguan, while Cadiling and Sabol were naturally less susceptible varieties. Sabol is a colored, awned variety, and the possession of pigment may have a certain correlation with resistance in this case. In Rizal Province, Macan Piña, an early variety, was found quite susceptible, and Khao Bai Sri, Apostol, Guinangang, Cruz, and Calibo III were so to a slight degree. Just how the varieties grown in the highlands would behave when planted in the lowlands, or vice versa, with respect to this kind of sterility, remains to be seen. Meanwhile, everything else being equal, it would seem advisable to substitute less or not at all affected varieties for the susceptible ones. In the Mountain Province, Cadiling and Sabol are grown as profitably as the susceptible Maletecan.

In October and November, 1932, field observations conducted at the Alabang Rice Experiment Station on 121 native and exotic varieties in 100-plant plot cultures during their flowering period proved that white sterility was prevalent. Of the total number of varieties observed, 91, or 75.2 per cent, showed this form of sterility in varying degrees, while 30, or 24.8 per cent, were apparently unaffected. Although varieties maturing at different periods were found susceptible, a preponderance of this flower affection was found more frequently and with a greater degree of severity among the early varieties than in the medium- or late-maturing varieties. Among the most seriously affected varieties are Royal from Java, Kathisod from Siam, and the native varieties Minalabon, Caviteña, and Bacao na Barayon. Of the varieties which apparently showed no evidence of sterility were Tongsan of Java, and the local varieties Diamante, Casicad, Bagsit, Carnero, Pulao, Ubanan, Baladong, Tapusan, Inagamang, Tinalahib, Kaongkoy, Kabonbon, Mulan-ay, Maghusay,

Barangcal, Binulinao, Lantec, Salomonay, Sempulec, and Sinandaang Araw, of which five are from the Mountain Province and the rest from various other parts of the Philippines. In order, however, to show a better appreciation of the extent of damage occasioned by white sterility, actual counts were made from twenty panicles taken at random from the 100-plant plots of the varieties listed in Table 1.

TABLE 1.—*Rice varieties showing the presence of white sterility, to a greater or lesser degree, as observed in the 1932–1933 season at Alabang, from twenty panicles picked at random.*

Variety name	Panicles counted	Average sterility	Approximate ratio of sterile to fertile flowers
		Per cent	
Sipot	20	14.96	1:13
Minalabon	20	24.40	1:3
Katilang	20	15.55	1:6
Royal	20	15.90	1:12
Magcumpol	20	17.74	1:6
Caviteña	20	21.75	1:6
Bacao na Barayon	20	20.33	1:6
Señora II	20	16.95	1:7
Baranay	20	14.43	1:7
Macan I	20	23.47	1:4

An examination of Table 1 will show the average proportions of the sterile and fertile flowers per panicle to be approximately from 1: 3 to 1: 13, depending on the variety, while the average percentage of sterility against the total number of grains formed was, from 14.43 to 24.40.

In Coimbatore, India, (5) white sterility was noted to be particularly bad on wild or semi-wild rices, and also obviously manifest on poor varieties. Pure lines were also affected to a varying extent. Long-awned varieties were, with two exceptions, found to be more easily affected. Weather conditions seem to have a direct influence on the occurrence of white sterility among early varieties, such as Macan Piña, Guinangang Str. 1 and Apostol, for instance, as has been observed in the Alabang Rice Experiment Station, confirming the findings of Ramiah, (5) in Coimbatore, who reported that sterility was quite prevalent among short-maturing varieties.

EVIDENCES OF CROSS STERILITY

Cross sterility was first observed at the Alabang Rice Experiment Station in July, 1928, in three natural hybrid plants in the strain test of Gopher, a variety of American origin (Plate 7, *d*). Except for the colored apiculus and large proportion of

empty grains which were more or less uniformly scattered among well-developed grains in the panicles, these natural hybrids were very similar to the normal Gopher type. They produced a total of 3,124 spikelets, of which 1,501 were normal and 1,623 sterile spikelets showed 1 : 1 ratio, with a deviation of 61.0 ± 18.8.

TABLE 2.—*Sterility in different rice hybrids as shown by the relative proportion of normal and sterile spikelets.*

Crosses	Progenies	Grains			Ratio	Deviation	Probable error
		Normal	Sterile	Total			
Gopher natural hybrids	3	1,501	1,623	3,124	1:1	61.00	±18.80
Baladong x Apostol	5	2,680	2,742	5,422	1:1	31.00	±24.82
Storm Proof x Apostol	3	745	2,018	2,763	1:3	54.25	±22.75

Similar sterility was found in two of the seven crosses made at the station(9) in 1928. From five F_1 plants of Baladong x Apostol cross (Plate 6, middle fig.) there were produced 2,680 normal and 2,742 sterile spikelets, thus deviating only by 31.00 ± 24.82 from the normal 1 : 1 ratio. The Storm Proof x Apostol cross produced three F_2 progenies, consisting of 745 normals and 2,018 sterile spikelets, or approximately a 1 : 3 ratio, the deviation being 54.25 ± 22.75.

An examination of the reproductive organs was made. It was found very difficult to differentiate one kind of ovary from the other in the early stage, even under the microscope. Normal pollen grains could be distinguished easily from the aborted ones, however.

Materials were obtained from two F_1 plants of Baladong x Apostol cross and from one F_1 plant of Storm Proof x Apostol. Ten mounts were made of each plant for the counting of the pollen grains. The results are given in Table 3.

TABLE 3.—*Sterility in different rice hybrids as shown by the relative proportions of functional and nonfunctional pollen grains*

Crosses	Counts	Average number of pollen grains[1]			Ratio	Deviation	Probable error
		Norm. or functional[a]	Nonfunctional [b] and [c]	Total			
Baladong x Apostol (733-1)	10	73.6	94.7	168.3	1:1	10.55	±4.60
Baladong x Apostol (733-2)	10	132.1	144.5	276.6	1:1	6.20	±5.60
Storm Proof x Apostol	10	19.3	105.6	124.9	1:3	11.93	±5.59

[1] ([a]) Large normal or functional pollen grains.
([b]) Small, nonfunctional pollen grains.
([c]) Shriveled or aborted pollen grains.

With the Baladong ♀ x Apostol ♂ cross in two cases the proportion of normal to aborted pollen grains was 1 : 1, and the deviation insignificant. On the other hand, the Storm Proof ♀ x Apostol ♂ cross showed 1 : 3 ratio with deviation of only 11.93 ± 5.59. In the latter cross three types of pollen grains were found: (*a*) large, normal or functional pollen grains; (*b*) small, nonfunctional pollen grains; and (*c*) shriveled, nonfunctional pollen grains. These pollen types fit well 1:2:1 ratio.

To determine the proportion of semisterile to normal or fertile plants in the F_2 generations, some F_2 seeds were grown from the natural hybrids and artificial crosses, and the results obtained

TABLE 4.—*Segregations of F_2 plants from different rice crosses, showing the proportion of semisterile and normal plants*

Crosses	Progenies	F_2 plants			Ratio	Deviation	Probable error
		Semisterile	Normal	Total			
Gopher natural hybrids	3	262	18	280	15:1	0.50	±2.73
Baladong x Apostol	4	349	110	459	3:1	4.75	±6.26
Storm Proof x Apostol	3	723	54	777	15:1	5.44	±4.55

therefrom are presented in Table 4. The Gopher natural hybrids produced 262 semisterile F_2 plants and 18 normally fertile plants in the ratio of 15: 1, the deviation being 0.50 ± 2.73. The Baladong x Apostol hybrids gave 349 semisterile F_2 plants and 110 fertile plants resulting in a ratio of 3: 1, and a deviation of 4.75 ± 6.26. The Storm Proof x Apostol hybrids produced 723 semisterile and 54 fertile plants in the second generation indicating a 15: 1 ratio and a deviation of 5.44 ± 4.55.

With the foregoing results it is not possible to give any conclusion as to the number of Mendelian factors determining this type of sterility, for the F_3 and succeeding generations were not carried out due to the transfer of the breeder to another project. Notwithstanding this fact, it may be inferred that semisterility in rice hybrids is hereditary in nature as will be subsequently shown in the observations of Messrs. J. O. Unite and G. M. Reyes in certain types of crosses in the F_3 and F_4 generations.

SUMMARY AND CONCLUSIONS

1. The sterility of rice herein reported is of two kinds and both are limiting factors of economic importance in rice production, as they affect the yields materially.

2. White sterility is of commoner occurrence in rice fields than in generally supposed and can be distinguished by the presence

in the panicle of undeveloped, empty, white florets occurring usually in groups in the terminal portions, although they may be found also in other parts of the panicle. Heretofore it has claimed little or no attention.

3. The loss from white sterility has been found to vary from 14.4 to 24.4 per cent in the varieties showing more or less severe affection in the lowlands (Alabang, Rizal), and it may be as high as 25 per cent, as was observed in the highlands (Trinidad, Mountain Province).

4. A preponderance of damage has been observed among the early- over that among the medium- and late-maturing varieties. In the light of these observations, it would seem expedient to plant the early varieties in irrigated districts a little later than usual so that they may not be affected by unfavorable local weather conditions in the vulnerable blooming period, to prevent much damage.

5. Several causes have been attributed to this form of sterility. While the writers are inclined to believe it is an inherent varietal character, it may be induced by adverse weather conditions affecting the vigor and fertilization of the rice plant.

6. There is, too, ample evidence that white sterility results from the formation of defective or degenerate reproductive organs in the panicle containing normal flowers.

7. Cross sterility, on the other hand, does not become clearly manifest until the panicles have reached a certain stage of maturity, and is characterized by the formation of empty, straw-colored flower glumes distributed among the normally developed grains in the panicle. The flowers apparently contain complete sex organs.

8. It is believed to be a hereditary character resulting through natural or artificial crossing of varieties possessing wide morphological characters or distantly related in inheritance; and it may arise from crosses exhibiting sterility in one or both parents.

9. Decreases in yield resulting from the occurrence of cross sterility have been estimated in two hybrid types at from 8.8 to 31.5 per cent and from 20.3 to 60.3 per cent. A tendency was noted for sterility to increase in ratio in the succeeding generations.

10. Experiments and observations on the resistance and susceptibility of rice varieties in different localities need to be made,

with a view to finding any possible relation between altitude or climatic factors and the incidence of sterility.

11. Meanwhile, with our present knowledge of the subject, it would seem advisable, if other conditions warrant it, to substitute less susceptible or unaffected varieties for the ones showing considerable sterility.

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ILLUSTRATIONS

Plate I

Rice panicles of lowland varieties (left to right) Caviteña, Minalabon, Baranay and Bacao na Barayon, showing the occurrence of white sterility at the terminal and basal portions. Photographed from dried specimens. About × 6.

Plate II

Dried panicles of lowland rice varieties (left to right) Macan I, Bacao na Barayon, Royal and Cabatiti exhibiting a more or less distributed or middle occurrence of white sterility. About × 6.

Plate III

FIG. 1. A young rice inflorescence emerging from the boot, obtained from Trinidad, Benguet, Mountain Province, showing early stages in the formation of partial sterility by the appearance of abnormally small, unfilled, white, chartaceous grains. Photographed from fresh specimens. About natural size.

2. Two dried panicles of Maletecan variety from the same locality, showing sterility at the terminal part and at the middle lateral branches. Note the shrunken sterile florets. Reduced in size.

Plate IV

FIG. 1. Portions of two panicles obtained from Mountain Province. The panicle to the left shows sterility observed within the enclosing boot. Note the sterility in the panicle at the right which occurs close to the base. About natural size.

2. Portions of two heads of Maletecan variety showing filling fertile grains and barren grains. Many of the latter have already dropped off. Slightly enlarged.

Plate V

A cross between Elon-elon ♀ x Inadhica ♂ rice varieties, showing the occurrence of sterility in the second generation hybrids indicated by the two panicles in the center and its presence in the male parent variety. Approximately × 6.3.

Plate VI

A cross between Baladong ♀ (left) x Apostol ♂ (right), showing the occurrence of sterility in the second generation indicated by the panicle in the middle. About × 0.5.

PLATE VII

Showing a hybrid (*b*) from artificial cross Storm Proof ♀ (*a*) and Apostol ♂ (*c*). Natural hybrid (*d*) from Gopher (*e*) and an unknown variety. About × 0.5.

TEXT FIGURES

FIG. 1. *a*, Portion of a rice spike of Guinangang Str. 1, obtained from a panicle still within the barrel, to show the comparative sizes of normal and sterile flowers, approximately × 3.9. *b*, Reproductive organs obtained from the third flower shown in *a*, possessing all the essential organs but having somewhat less feathery or poorly developed stigmas and the filaments of the abortive stamens not fully extended, about × 6.4.

2. Imperfect pollen grains obtained from sterile florets of the same variety, drawn with a camera lucida to show morphological structures: *a*, Fresh pollen grains without contents; *b*, shriveled pollen grains assuming various shapes; *c*, a burst pollen grain, × 653; *d*, a normal pollen grain to show the difference, × 653; *e*, a highly magnified sterile pollen grain without contents, showing the germ pore at the periphery, × 1,300; *f*, a front view of the germ pore, × 1,300.

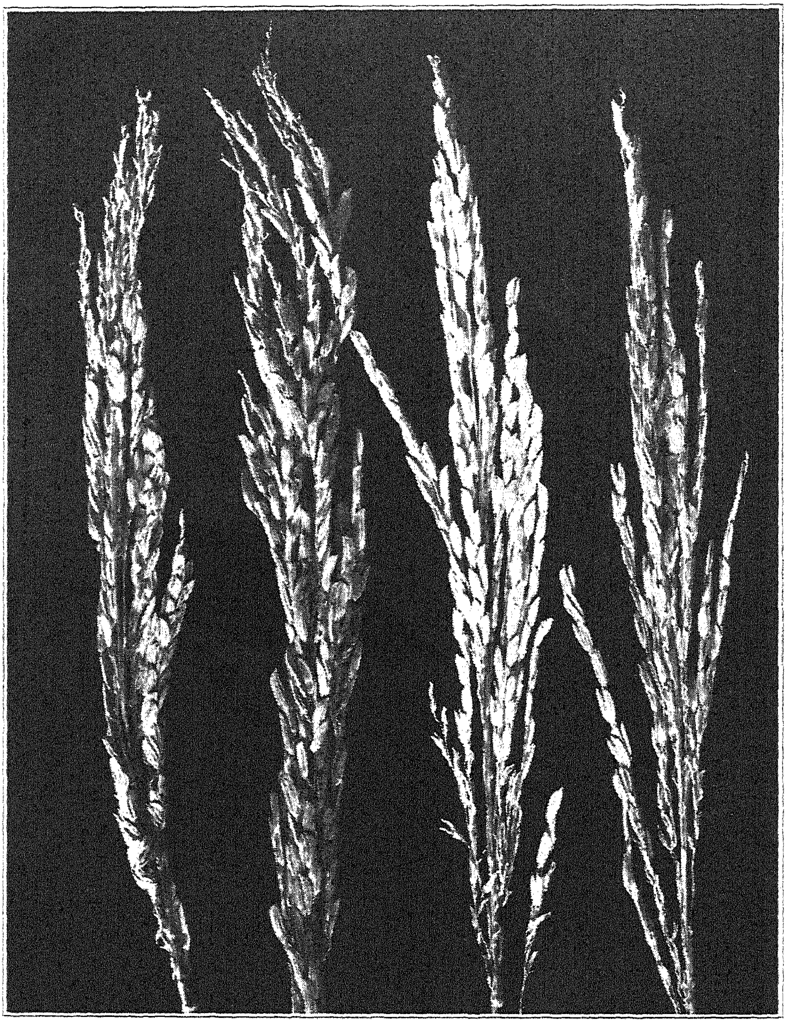

PLATE I

PLATE II

1

2

PLATE III

1

2

PLATE IV

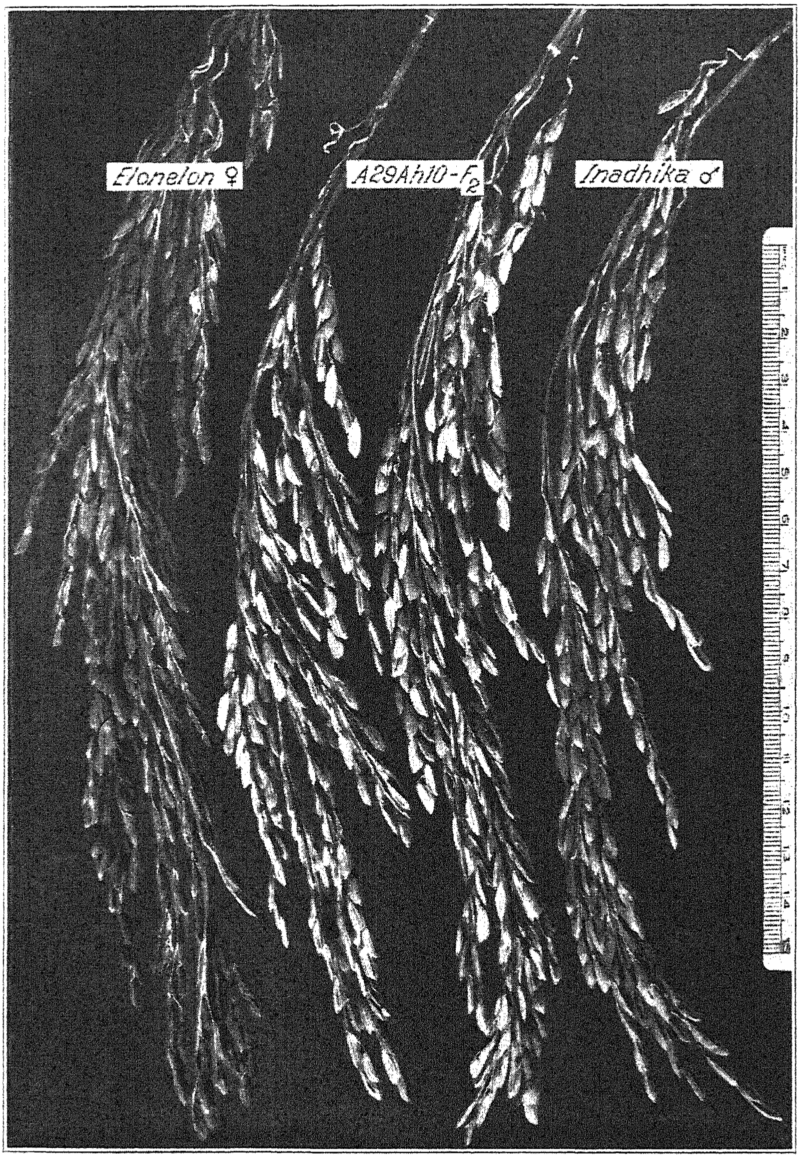

PLATE V

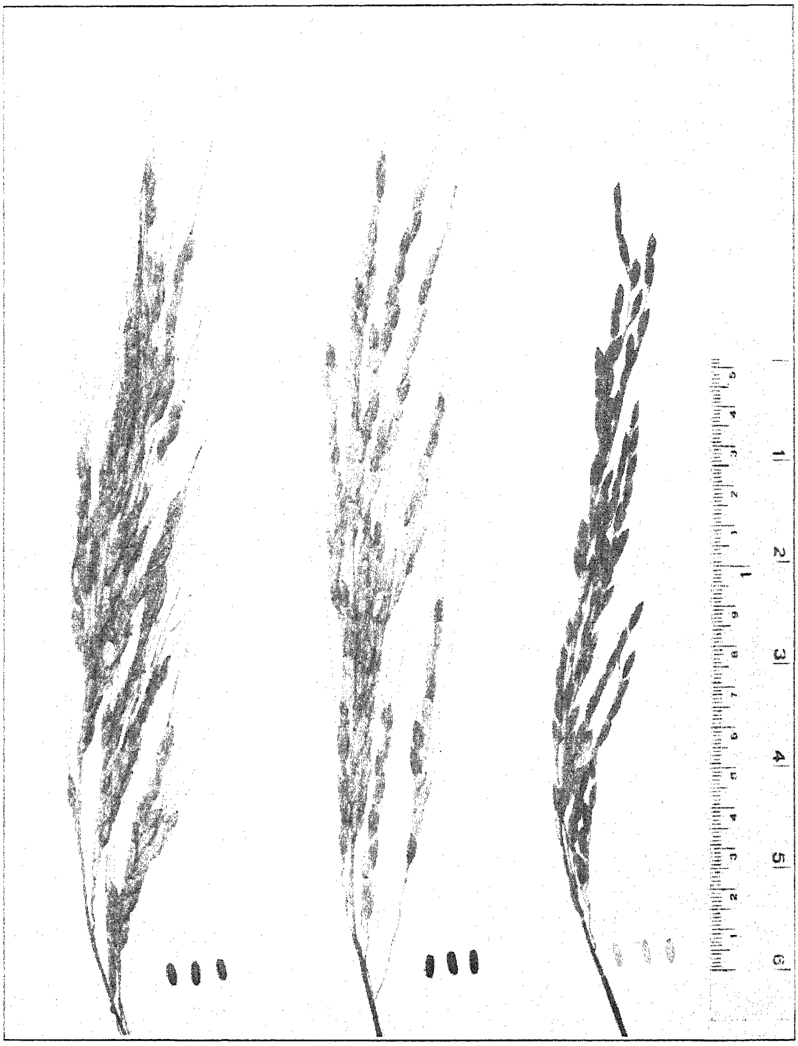

PLATE VI

PLATE VII

EXPERIMENTS IN VIRGINIA CIGARETTE TOBACCO PRODUCTION DURING THE 1932–1933 SEASON

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FOUR PLATES

The present report covers only our experiments with Virginia tobacco. It has been decided to submit the experiments in the production of cigarette tobacco in two reports because there are significant differences in the culture as well as in the development of the Turkish and Virginia types of cigarette tobacco.

The production of Virginia cigarette leaf tobacco in the Philippines, although new, is now an established industry. It was only during the tobacco season just ended that farmers in central Luzon and La Union Province grew it on a commercial scale but the product turned out was, on the whole, so satisfactory; such good prices—mostly 20 pesos per quintal—were paid, that whereas only 11,000 kilos were produced, during the coming 1933–1934 season this quantity will probably be fifty times as great. As a matter of fact most of the prospective crops are contracted for and some manufacturers and leaf-tobacco dealers have formed a corporation to raise the product themselves.

Because of this tremendous interest manifested in the production of Virginia cigarette leaf tobacco, we believe it the proper time to publish our report on the experiments on the production of this product during the 1932–1933 season just ended, conducted at various places, mostly at the Alabang Rice Station, Muntinlupa, Rizal Province, Luzon, because of better facilities there. These experiments were virtually continuations of those conducted during the previous 1931–1932 season as reported in this Journal in its issue for the third quarter, of 1932.(2) This being the fact, the experimental procedures are purposely omitted in this paper. Neither is any literature on the subject reviewed, as such articles were adequately covered in the senior author's report in 1930.(1)

EXPERIMENTS CONDUCTED AT THE ALABANG RICE STATION

The field was the same as that used during the previous season and the weather conditions were practically the same also.

Varieties used.—The standard varieties Orinoco, Adcock, North Carolina Bright Yellow, Big Warne, and Conqueror were used for the variety tests. The varieties White Stem Orinoco, Goldleaf, Longleaf Gooch, and Warne were propagated for further standardization, while the native Vizcaya was also propagated for further observation in the possibility of producing the Virginia type of cigarette tobacco out of native stock.

Cultural operations.—The seed was sown October 5, and the plants set out in the field December 12, 1932. The field was prepared by plowing and harrowing the land twice with a tractor. A native plow drawn by a carabao was used in making the furrows. As usual the planting distance was 70 centimeters between the plants and 80 centimeters between the rows. The field was cultivated after planting with the native plow at intervals of two weeks for about two months, when the plants were about to show signs of flowering.

Control of pests and diseases.—The only serious pest during the season was the common red ant, which caused the first sowings of seeds almost to fail by carrying the seeds away. Subsequent harm by the pest, however, was prevented by the use of bait made of three parts corn meal and one part of sugar with just enough water to form a mash. This bait was merely dropped around the tobacco beds.

Regular dusting of the plants with calcium arsenate mixed with sixteen parts sterilized road dust and observance of simple sanitation in the handling of the plants throughout their growing period, helped much in minimizing the attacks by the usual tobacco worms and diseases.

Variety tests.—Because of the sloping topography of the field, a row of 100 plants was taken for a plot and replicated 10 times. The yields were taken separately from each row, then computed on a hectare basis. The variety North Carolina Bright Yellow was used as check. In determining the significance of the yield differences, the mean, the probable error of the mean, and the probable error of the difference were computed in all cases. (See results in Table 1.)

The percentage weight of cured leaves on fresh green leaves for each variety was also determined. The leaves were harvested one by one as they matured and their weights were taken

immediately after harvesting. The weights were again taken after curing, the weighing being always done at about 3 o'clock in the afternoon. The ratios of the cured leaves and the green leaves, as expressed in percentages, the mean, the probable error of the mean, and the probable error of the difference were computed. (See results in Table 2.)

Harvesting experiments.—The relation of the color of the leaves in the fields and the color of cured leaves was again studied in order to check the results of last year. The varieties studied were North Carolina Bright Yellow, Adcock, Orinoco, and the native Vizcaya. After the leaves were harvested they were classified into three groups according to color; namely, (*a*) dark green, (*b*) light green, and (*c*) ranging from light yellow to bright yellow. All the leaves used in this study were cured in the sun. (See results in Table 3.)

Curing experiments.—The same methods as those used in the previous season were adopted; namely, the leaves were cured (*a*) in the sun, (*b*) in a nipa shed, (*c*) in a galvanized-iron shed, and (*d*) in a nipa shed and then in the sun. The number of days it took the leaves to cure by each method was recorded. Notes on the color of the leaves produced from each method were also taken, each method being given three trials. (See results in Table 4.)

In order to find some means whereby the cost of producing flue-cured Virginia tobacco can be reduced, the flue-curing barn constructed at Singalong was equipped with galvanized-iron pipes instead of cast-iron as the ones used in Isabela and reported on in our previous paper.(2) It was during the early part of May, 1933, that some leaves produced in Alabang were cured in this barn.

Flowering observations.—The time when each variety produced flowers was closely observed. Eleven varieties—ten American and one native—were studied. (See results in Table 5.) The observations for last season have been incorporated in this table for comparison.

STATISTICAL STUDIES OF QUANTITATIVE CHARACTERS

In order to determine further the reliability of the variety tests conducted at Alabang, statistical studies of the more important quantitative characters of the standard varieties were made; namely, (*a*) number of standard leaves, (*b*) total height of plants, (*c*) length of leaves, and (*d*) width of leaves.

For the variety tests conducted at the Maligaya Rice Station, Muñoz, Nueva Ecija, only the variety Adcock was statistically studied because it is the only variety thus far that has given a satisfactory performance there.

At Alabang the number of standard leaves per plant for each variety was counted. Twenty-five individuals picked at ramdom were used for each variety, except for the Big Warne, for which there were only fifteen. The counting of leaves was made when the plants were in full bloom. (See results in Table 6.)

In the study of height of plants the same individuals shown in Table 6 were used. In taking the height the measurement was made from the ground to the tip of the flower head. (See results in Table 7.)

The leaf length and width are based on one middle standard leaf of the same plants. (See results in Tables 8 and 9.)

At Maligaya, the same procedure employed at Alabang was used in the study of the quantitative characters made (See results in Table 10).

SPECIAL CASES IN REGIONS UNDER THE FIRST TYPE OF PHILIPPINE CLIMATE

In our previous report we emphasized the fact that the regions in the Philippines most suitable for the culture of cigarette tobacco are those falling under the First Type of climate (according to the classification of the Weather Bureau), that is characterized by two pronounced seasons, dry in winter and spring and wet in summer and autumn. We also mentioned that, besides being of this climatic type, the land must be well drained, all investigations having been performed in open lands less than 50 meters in elevation above sea level.

During the 1932–1933 season, however, we had occasion to note that our First Type of climate is affected by high altitude and mountainous surroundings. It happened during the season that some farmers raised their crops at an elevation of over 1,000 feet in Batangas and one farmer in a small valley surrounded by mountains in La Union. As a result new problems confronted us. In the former, the leaves could not be left in the open in the evening because of invariable heavy dew at night, while in the latter, although there was no dew at night, the leaves simply refused to cure yellow.

DISCUSSION OF RESULTS

Yields per hectare.—Referring to Table 1 it will be noted that the two varieties which gave the highest average yields per hectare were Orinoco, 43.82 ± 2.09 quintals, and North Carolina Bright Yellow, 41.56 ± 1.89. The other varieties, with their corresponding yields were as follows: Adcock, 33.8 ± 1.24; Big Warne, 30.30 ± 1.84; and Conqueror, 27.69 ± 0.98 quintals. By referring to the same table it is evident that North Carolina Bright Yellow is superior to Adcock, Big Warne, and Conqueror, because the mean difference against Adcock is more than three times the probable error of the difference, almost ten times that of Big Warne and more than six times that of Conqueror. On the other hand, Orinoco is better than North Carolina Bright Yellow. The difference in yield, however, between the two varieties is insignificant, because the probable error of the difference is even greater than the mean difference.

The yields obtained this season for almost all the varieties studied are generally larger than those of last season except that of the Adcock, which is about 7 quintals less. Take the North Carolina Bright Yellow, for instance, the yield of this variety last season was only 20 quintals per hectare, while this year it is twice as much. The yield of Conqueror and Big Warne increased also to some extent. The main reason for the increase in yield this year is that the field was plowed deeper and with a tractor. It is also possible that because the varieties are all of foreign origin, their performance improves as they become better acclimatized to Philippine conditions.

Relative weight of green and cured leaves.—It will be observed in Table 2 that the varieties studied vary in percentages of cured weight of leaves. North Carolina Bright Yellow and Adcock do not differ significantly in this character, the mean difference being only about twice the probable error of the difference. On the other hand, the former is superior to both Conqueror and Orinoco, having mean differences of approximately nine and ten times the probable error of the difference, respectively. Big Warne, however, is superior to North Carolina Bright Yellow in this respect, the mean difference in favor of Big Warne being more than four times the probable error of the difference.

Harvesting experiments.—As shown in Table 3 the color of the leaves at the time of harvesting has some bearing on the color

of the cured leaves. In the varieties studied the dark green leaves turned either light brown or dark brown or remained green. The light green leaves, on the other hand, turned bright yellow in the case of North Carolina Bright Yellow, light yellow in Orinoco, and from light brown to light yellow in Adcock and Vizcaya. The leaves with light or bright yellow color when harvested turned light brown or light yellow in the case of North Carolina Bright Yellow and light brown or dark brown in the other varieties. Cutting down the whole stalk of the plants to the base in harvesting gave unsatisfactory results. Only those leaves close to the base of the stalks turned yellow and all the top leaves turned either light brown or dark brown. It is evident from this that the green color of the leaves is the optimum criterion in harvesting.

Curing experiments.—Table 4 gives the four methods of curing tried and shows that each method had practically the same effect on the color of the leaves. If there were differences at all they were too insignificant to be worth consideration. In other words any one of them can be used to give satisfactory results in places having conditions similar to those in Alabang. Complete sun-curing, however, has the advantage over the other methods because of the time gained. In duration of time, the methods may be named in their order of shortness as follows: First, in the sun; second, in a nipa shed then in the sun; third, in a galvanized-iron shed; and fourth, in a nipa shed.

In Alabang, according to our observations from the middle of February to the middle of May, complete sun-curing can be used to advantage, since during this period there is practically no rain or dew which might affect the process while the leaves are in the open without covers.

By subjecting the leaves in the flue-curing barn to the same graduated temperature up to a maximum of 66° C. as described in our previous report,(2) the curing turned out successful.

Some additional valuable points were gained in this test in connection with the flue-curing of Virginia tobacco. The cost of production is reduced considerably by the use of galvanized-iron pipes, this material being very much cheaper than cast iron. Galvanized iron being also easier to heat, much saving is effected in the consumption of fuel.

Although flue-curing of Virginia tobacco is indispensable in regions with short dry seasons like Cagayan Valley, yet it pays to erect a flue-curing barn even in regions where sun-curing is

possible because of a long dry season. In these regions, the flue-curing barn will insure a bigger crop and a full harvest by rendering possible an early as well as a late crop. It will likewise insure the proper curing of the regular crop in case of an early or delayed rainy season. Furthermore, since crop diversification should be practiced, the barn will be handy for the proper curing or dehydration of other profitable farm products like peanuts, onions, ginger, etc., the moisture content of which must be regulated for effective preservation.

Observation on the period of flowering.—A knowledge of the period of flowering of any crop is of vital importance to plant breeders. In order to cross two varieties, their blooming periods must coincide. Correct information on the period of maturity of the different varieties must be in hand because in some localities early maturing varieties are in demand. In Table 5 it will be seen that for two successive years, at least some varieties had more or less a fixed blooming period. The time of flowering this year of the foreign varieties under study ranges from 95 to 149 days from the time of sowing the seed.

The knowledge is also a valuable basis for correlating harvesting and maturity periods.

Interpretation of statistical data.—The following are the analyses and interpretation of statistical data obtained at Alabang.

(*a*) The number of standard leaves is an important character of the tobacco plant. Other factors being equal, a plant with a greater number of leaves will have a larger yield than a plant with less. In the selection of strains, especially for breeding purposes, this character must always be taken into consideration.

Referring to Table 6 it will be readily seen that the varieties studied vary in the average number of leaves per plant. The varieties, with their corresponding average number of leaves, may be named in their order as follows: Orinoco, 25.36 ± 0.49; Adcock, 28.36 ± 0.48; North Carolina Bright Yellow, 19.10 ± 0.36; Big Warne, 1706 ± 0.24 and Conqueror, 15.12 ± 0.29. On the basis of the coefficients of variability it is evident that the variety Conqueror and to a certain extent Adcock need further inbreeding for the character of number of leaves.

(*b*) Table 7 shows that some varieties are taller than others. Big Warne, for instance, is approximately 20 centimeters taller than Conqueror with mean heights of 132.33 ± 2.17 and 112.00 ± 2.98 centimeters, respectively. On the other hand, Adcock and North Carolina Bright Yellow are nearly as tall as Big

Warne. Conqueror with a coefficient of variability of 19.61 ± 1.01 per cent and a standard deviation of 22.08 ± 2.11 is the only variety needing further inbreeding. Using both the standard deviation and coefficient of variability as bases of comparison, the other varieties may be enumerated in their order of variability as follows: North Carolina Bright Yellow, Orinoco, Big Warne, and Adcock. Adcock is the best fixed in this character, since it has only a 7.6 per cent ± 0.37 coefficient of variability.

(*c*) Referring to Table 8 it will be seen that the varieties studied, with their corresponding mean lengths of leaves come in the following order: Big Warne, 53.46 ± 1.15; North Carolina Bright Yellow, 48.16 ± 0.74; Conqueror 46.32 ± 1.13; Adcock, 41.76 ± 0.85; and Orinoco, 41.36 ± 1.24 centimeters. The coefficient of variability shows that Orinoco with 22.17 ± 2.32 per cent, and Conqueror, 18.07 ± 0.92, are the most variable while North Carolina Bright Yellow with 11.39 ± 0.55 per cent is the least variable.

(*d*) In Table 9 it is interesting to note that Orinoco and Conqueror are as variable in width of leaves as in length of leaves, their coefficients of variability being 25.86 ± 1.40 and 23.28 ± 1.23 per cent, respectively, while Big Warne with 12.03 ± 0.76 per cent is the least variable. North Carolina Bright Yellow has the broadest leaves with a mean of 26.44 ± 0.55 centimeters and Orinoco has the narrowest, 11.52 ± 0.40 centimeters.

The behavior of the variety Adcock at Maligaya, as may be observed in Table 10, indicates that its 16.94 ± 0.60 coefficients of variability for number of leaves and 24.95 ± 0.89 for width of leaves, require further selection for these characters.

Special cases in regions under the first type of Philippine climate.—In regions of about 1,000 feet elevation but not surrounded by mountains, the yellow curing of the leaves was attained by taking the trouble to bring the poles or sticks into the shed at sunset until they became too brittle for handling, when they were placed permanently in a galvanized-iron shed until they were thoroughly cured.

In the case of the lowlands surrounded by mountains, the problem is still unsolved. It is unfortunate that when this trouble was discovered the season was about to end and there was no time to try other methods of curing.

Identification of the standard Philippine grown Virginia varieties.—The five Virginia varieties used in the variety test al-

ready discussed are considered standard under Philippine conditions, inasmuch as out of the numerous varieties introduced into the country for the purpose of developing varieties to supply a local aromatic cigarette leaf tobacco product, these varieties not only have thrived locally but their yields, curing qualities, and aroma are very satisfactory.

As these varieties are now being grown all over central Luzon and the Ilocano provinces, it is necessary that a means for their identification be prepared. And for this purpose there is nothing better than the following simple analytical key:

a. Plants short, less than 125 cm............ B.
  b. Leaves lanceolate, less than 30 per cent breadth index........ ORINOCO.
  bb. Leaves, broadly ovate, more than 50 per cent breadth index, few. CONQUEROR.

aa. Plant medium more than 125 cm............ B.
  b. Leaves large, more than 50 cm., ovate............ BIG WARNE.
  bb. Leaves medium, less than 50 cm............ C.
    c. Leaves ovate-elliptical .... ADCOCK.
    cc. Leaves broadly ovate, more than 50 per cent breadth index. NORTH CAROLINA BRIGHT YELLOW.

SUMMARY AND CONCLUSIONS

1. Most of the varieties under study have had larger yields during this season than during the previous one. The increase in yields may have been due either to the more intensive cultivation given to the plants this season or, since it is only the second year of the introduction of most of these varieties, possibly they are still in the process of acclimatization.

2. Orinoco and North Carolina Bright Yellow produced the highest yield of cured leaves per hectare or more than 40 quintals each.

3. The least variable variety, with respect to height of plants, is Adcock; number and width of leaves, Big Warne; and length of leaves, North Carolina Bright Yellow. Big Warne seems to be the most uniform variety with reference to these characters.

4. The proper time to harvest the leaves is when they assume a light green color. At this stage the leaves will turn yellow in curing.

5. Under Alabang conditions the different methods of curing produced the same effect on the color of the leaves. Complete sun-curing has the advantage over the other methods because the leaves dry faster.

6. In high altitudes the leaves should not be left in the open at night. When they become too brittle to handle, they should be left in galvanized-iron buildings until thoroughly dried or cured.

7. In flue-curing, the use of galvanized-iron pipes instead of cast-iron is preferable in that it is not only much cheaper but also easier to heat.

8. The time of flowering of the ten different foreign cigarette tobacco varieties and one native variety under study ranges between three and five months.

9. As regards color of leaves (yellowness), North Carolina Bright Yellow is superior.

10. Among the varieties studied, the leaves of Orinoco had the highest moisture content and the leaves of Big Warne had the least. Their average cured weights in percentage on the basis of green weights were 13.82 ± 0.38 and 21.25 ± 0.47.

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TABLE 1.—*Yield of five cigarette tobacco varieties tested at the Alabang Rice Station during the season 1932–1933*

NORTH CAROLINA BRIGHT YELLOW (CONTROL)

Row	Quintals per hectare	d	d^2	
A-1	45.71	+ 4.15	17.22	
A-2	36.78	— 4.78	22.84	
A-3	38.56	— 3.00	9.00	
A-4	56.45	+14.89	221.71	
A-5	31.78	— 9.78	95.64	M=41.56 ±1.89
A-6	57.49	+15.93	253.76	
A-7	39.64	— 1.92	3.69	
A-8	38.21	— 3.35	11.22	
A-9	34.64	— 6.92	47.88	
A-10	36.42	— 5.14	26.41	
Average	41.56	....	Σd^2 709.37	

TABLE 1.—*Yield of five cigarette tobacco varieties tested at the Alabang Rice Station during the season 1932–1933*—Continued

ADCOCK

Row	Quintals per hectare	d	d^2	
B-1	31.78	− 2.10	4.41	
B-2	28.92	− 4.96	24.60	
B-3	42.49	+ 8.61	74.13	
B-4	27.85	− 6.03	36.36	M=33.88 ±1.24
B-5	36.07	+ 2.19	4.79	
B-6	26.78	− 7.10	50.41	A=41.56 ±1.89
B-7	28.57	− 5.31	28.19	B—33.88 ±1.24
B-8	35.71	+ 1.83	1.51	
B-9	41.42	+ 7.54	56.85	7.68 ±2.28
B-10	39.28	+ 5.40	29.16	
Average	33.88	....	Σd^2 310.41	

BIG WARNE

Row	Quintals per hectare	d	d^2	
C-1	38.78	+ 8.48	71.91	
C-2	21.78	− 8.52	72.59	
C-3	48.21	+17.91	320.76	
C-4	28.57	− 1.73	2.99	M=30.30 ± 1.84
C-5	23.92	− 6.38	40.70	
C-6	31.78	+ 1.48	2.19	A—41.56 ±1.89
C-7	19.99	−10.31	106.29	C —30.30 ±1.84
C-8	35.71	+ 5.41	29.26	
C-9	29.28	− 1.02	1.04	11.26 ±2.64
C-10	24.99	− 5.31	28.19	
Average	30.30	....	Σd^2 675.92	

CONQUEROR

Row	Quintals per hectare	d	d^2	
D-1	30.35	+ 2.66	7.07	
D-2	32.76	+ 5.07	25.70	
D-3	25.35	+ 2.34	5.47	
D-4	28.21	+ 0.52	0.27	M=27.69 ±0.98
D-5	26.07	− 1.62	2.62	
D-6	33.92	+ 6.23	38.81	A—41.56 ±1.89
D-7	28.92	+ 1.23	1.51	D—27.69 ±0.98
D-8	30.35	+ 2.66	7.07	
D-9	20.71	− 6.98	48.72	13.87 ±2.13
D-10	20.35	− 7.34	53.87	
Average	27.69	....	Σd^2 191.11	

ORINOCO

Row	Quintals per hectare	d	d^2	
E-1	66.22	+12.40	153.76	
E-2	55.35	+11.82	139.71	
E-3	35.71	− 8.17	66.74	
E-4	33.92	− 9.90	98.01	M=43.82 ±2.09
E-5	31.42	−12.40	153.76	
E-6	34.64	− 9.18	84.27	E—43.82 ±2.09
E-7	48.20	+ 4.38	19.18	A—41.56 ±1.89
E-8	49.64	+ 5.82	33.87	
E-9	48.82	+ 5.00	25.00	2.26 ±2.82
E-10	34.28	− 9.54	91.01	
Average	43.82	....	Σd^2 865.31	

TABLE 1.—*Yield of five cigarette tobacco varieties tested at the Alabang Rice Station during the season 1932–1933*—Continued

SUMMARY OF TABLE 1

Variety name	Mean	Difference in favor of control
North Carolina Bright Yellow (control)	41.56±1.89	
Adcock	33.88±1.24	7.68±2.28
Big Warne	30.30±1.84	11.26±2.64
Conqueror	27.69±0.98	13.87±2.13
Orinoco	43.82±2.09	+2.26±2.82

TABLE 2.—*Relative weight of cured and green leaves in five cigarette tobacco varieties*

NORTH CAROLINA BRIGHT YELLOW (CONTROL)

Determination number	Cured leaves in green leaves	d	d^2	
	Per cent			
A-1	17.95	—0.92	0.8464	
A-2	19.97	+1.10	1.2100	
A-3	20.79	+1.92	3.6864	
A-4	19.07	+0.20	0.0400	
A-5	20.05	+1.18	1.3924	M=18.87±0.2640
A-6	19.59	+0.72	0.5184	
A-7	18.37	—0.50	0.2500	
A-8	17.42	—1.45	2.1025	
A-9	18.57	—0.30	0.0900	
A-10	16.95	—1.92	3.6864	
Average	18.87		Σd^2 13.82	

ADCOCK

B-1	16.52	—1.42	2.0164	
B-2	15.61	—2.33	5.4289	
B-3	16.03	—1.91	3.6481	M=17.94±0.3649
B-4	17.41	—0.53	0.2809	
B-5	17.72	—0.22	0.0484	A—18.87±0.2640
B-6	17.75	—0.19	0.0361	B—17.94±0.3649
B-7	21.15	+3.21	10.3041	
B-8	18.65	+0.71	0.5041	0.93±0.4503
B-9	19.46	+1.52	2.3104	
B-10	19.17	+1.23	1.5129	
Average	17.94		Σd^2 26.09	

BIG WARNE

C-1	21.03	—0.22	0.0484	
C-2	21.53	+0.28	0.0784	
C-3	16.74	—4.61	21.2521	M=21.25±0.4732
C-4	21.50	+0.25	0.0625	
C-5	23.54	+2.29	5.2441	C—21.25±0.4732
C-6	22.86	+1.61	2.5921	A—18.87±0.2640
C-7	19.12	—2.13	4.5369	
C-8	22.16	+0.91	0.8281	2.38±0.5417
C-9	20.00	—1.25	1.5625	
C-10	24.05	+2.85	8.1225	
Average	21.25		Σd^2 44.32	

TABLE 2.—*Relative weight of cured and green leaves in five cigarette tobacco varieties*—Continued

CONQUEROR

Determination number	Cured leaves in green leaves	d	d^2	
	Per cent			
D-1	16.76	+0.96	0.9216	
D-2	14.79	—1.01	1.0201	
D-3	15.10	—0.70	.4900	M=15.80± 0.2008
D-4	15.46	—0.34	.1156	
D-5	15.70	—0.10	.0100	A—18.87±0.2640
D-6	14.53	—1.27	1.6129	D—15.80±0.2008
D-7	15.75	—0.05	.0025	
D-8	15.67	—0.15	.0225	3.07±0.3316
D-9	16.91	+1.11	1.2321	
D-10	17.40	+1.60	2.5600	
Average	15.80		Σd^2 7.99	

ORINOCO

Determination number	Cured leaves in green leaves	d	d^2	
E-1	17.91	+4.09	16.7281	
E-2	13.00	—0.82	.6724	
E-3	11.47	—2.35	5.5225	M=13.82±0.3842
E-4	14.33	+0.51	.2601	
E-5	15.40	+1.58	.3364	A—18.87±0.2640
E-6	14.59	+0.77	.5929	E—13.82±0.3842
E-7	13.37	—0.45	.2025	
E-8	13.62	—0.20	.0400	5.05±0.4661
E-9	12.50	—1.32	1.7424	
E-10	12.05	—1.77	3.1329	
Average	13.82		Σd^2 29.23	

SUMMARY OF TABLE 2

Variety name	Mean	Difference in favor of control
North Carolina Bright Yellow (control)	18.87±0.2640	
Adcock	17.94±0.3649	0.93±0.4503
Big Warne	21.25±0.4732	+2.38±0.5417
Conqueror	15.80±0.2008	3.07±0.3316
Orinoco	13.82±0.3842	5.05±0.4661

TABLE 3.—*The relation of the color of the leaves in the field and the color of the cured leaves* [a]

Variety name	Color of leaves when harvested: 1. Dark green	2. Light green	3. Light yellow to bright yellow	Cutting the entire stock
	Color of cured leaves			
North Carolina Bright Yellow.	Light brown to dark brown.	Bright yellow.	Light brown to light yellow.	In nearly all cases only the sand leaves and a lower standard leaves turned either light yellow or bright yellow. All the rest turned either light brown or dark brown.
Adcock.	Dark green to dark brown.	Light brown to light yellow.	Light brown to dark brown.	
Philippine Vizcaya.	Dark green to dark brown.	Light brown to light yellow.	Light brown to dark brown.	
Orinoco.	Dark green to dark brown.	Light yellow.	Light brown to dull yellow.	
Samsoun Bafra.	Light brown to dark green.	Bright yellow.	Light brown to light yellow.	

[a] The results in this table were based on at least five trials.

TABLE 4.—*Effect of the different methods of curing on the color of the leaves and the number of days it takes to cure the leaves* [a]

Variety name	Method of curing											Remarks
	1. In the sun		2. Under nipa shed			3. Under galvanized iron roof			4. Under nipa shed and then in the sun			
	Average number of days to cure the leaves	Color of leaves in the order of yellowness	Average number of days to cure the leaves	Difference in favor of method No. 1	Color of leaves in the order of yellowness	Average number of days to cure the leaves	Difference in favor of method No. 1	Color of leaves in the order of yellowness	Average number of days to cure the leaves	Difference in favor of method No. 1	Color of leaves in the order of yellowness	
North Carolina Bright Yellow	21.0	I	26.3	5.3	I	23.3	2.3	I	21.3	0.3	I	In general the color of the leaves for each variety in the four methods of curing were practically the same.
Adcock	15.6	II	23.3	7.7	II	23.0	7.4	II	17.6	2.0	II	
Orinoco	19.3	III	28.3	9.0	III	25.0	5.7	III	26.6	7.3	III	
Vizcaya	17.6	IV	24.6	7.0	IV	24.6	7.0	IV	20.0	2.4	IV	

[a] The figures in this table are averages of three trials.

TABLE 5.—*Showing the number of days it takes the different cigarette tobacco varieties to produce flowers under Alabang conditions*

Variety name	1931–1932			1932–1933		
	Date of sowing	Flowers appeared	Days from sowing to flowering	Date of sowing	Flowers appeared	Days from sowing to flowering
North Carolina Bright Yellow	10–14–31	1–28–32	106	9– 7–32	12–15–32	99
White Stem Orinoco	10–14–31	1–20–32	98	9– 7–32	12–18–32	102
Goldleaf	10–14–31	1–26–32	104	9– 7–32	12–15–32	99
Longleaf Gooch	10–14–31	1–25–32	103	9– 7–32	12–26–32	110
Conqueror	10–14–31	2–13–32	122	9– 7–32	12–16–32	100
White Burley	....	....	....	9– 7–32	1– 2–33	117
Orinoco	....	....	....	9– 7–32	2– 3–33	149
Philippine Vizcaya	....	....	....	9– 7–32	2–21–33	167
Adcock	10–14–31	2–13–32	122	9–13–32	12–26–32	104
Warne	10–14–31	1– 1–32	79	9–13–32	12–17–32	95
Big Warne	10–14–31	1–27–32	105	9–13–32	1–10–33	119

TABLE 6.—*Frequency distribution of standard leaves per plant in five cigarette tobacco varieties raised in Alabang*

Variety name	Class centers for number of standard leaves														
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	Total
North Carolina Bright Yellow	....	....	1	3	10	6	2	3	....	....	....	....	....	....	25
Adcock	....	....	....	2	2	1	6	6	3	4	1	....	....	....	25
Big Warne	....	....	1	6	7	1	....	....	....	....	....	....	....	....	15
Conqueror	3	4	4	5	8	1	....	....	....	....	....	....	....	....	25
Orinoco	....	....	....	1	0	0	8	4	4	4	1	2	0	1	25

	Mean	Standard deviation	Coefficient of variability
North Carolina Bright Yellow	19.10±0.35	2.57±0.24	13.45±0.77
Adcock	23.36±0.48	3.58±0.34	15.32±0.76
Big Warne	17.06±0.24	1.39±0.17	8.14±0.51
Conqueror	15.12±0.39	2.91±0.28	19.24±0.97
Orinoco	25.36±0.49	3.65±0.35	14.39±0.71

TABLE 7.—*Frequency distribution of height of plants in five cigarette tobacco varieties raised at Alabang*

Variety name	Class centers for height of plants in cm								
	85	90	95	100	105	110	115	120	125
North Carolina Bright Yellow	......	......	......	1	3	1	3	0	3
Adcock	......	......	......	......	......	......	3	3	3
Big Warne	......	......	......	......	......	......	......	4	2
Conqueror	3	2	3	3	1	1	2	1	2
Orinoco	......	......	2	3	2	5	5	4	0

Variety name	Class centers for height of plants in cm								
	130	135	140	145	150	155	160	165	Total
North Carolina Bright Yellow	5	3	1	2	1	1	1	......	25
Adcock	9	1	3	2	0	1	......	......	25
Big Warne	4	1	1	1	1	0	0	1	15
Conqueror	0	1	2	4	......	......	......	......	25
Orinoco	2	0	0	1	1	......	......	......	25

Variety name	Mean cm	Standard deviation	Coefficient of variability
North Carolina Bright Yellow	127.80±2.15	15.92±1.52	12.48±0.61
Adcock	130.00±1.33	9.88±0.94	7.60±0.37
Big Warne	132.33±2.17	12.49±1.54	9.43±0.59
Conqueror	112.60±2.98	22.08±2.11	19.61±1.01
Orinoco	114.40±1.80	13.37±1.28	11.44±0.56

TABLE 8.—*Frequency distribution of length of leaves in five cigarette tobacco varieties raised at Alabang*

Variety name	Class centers for length of leaves in cm									
	30	32	34	36	38	40	42	44	46	48
North Carolina Bright Yellow	.....	.....	.....	.....	1	2	4	2	0	3
Adcock	.....	2	1	4	4	1	3	2	3	1
Big Warne	.....	.....	.....	.....	.....	1	0	0	1	2
Conqueror	.....	.....	.....	5	1	2	3	1	2	1
Orinoco	3	5	1	0	2	1	1	4	1	3

Variety name	Class centers for length of leaves in cm								Total
	50	52	54	56	58	60	62	64	
North Carolina Bright Yellow	2	7	2	1	1	.....	.....	.....	25
Adcock	0	3	1	.....	.....	.....	.....	.....	25
Big Warne	2	1	3	0	2	0	1	2	15
Conqueror	3	1	3	0	1	0	0	2	25
Orinoco	1	0	1	0	1	.....	.....	.....	25

Variety name	Mean	Standard deviation	Coefficient of variability
North Carolina Bright Yellow	48.16±0.74	5.49±0.52	11.39±0.55
Adcock	41.76±0.86	6.74±0.60	15.23±0.76
Big Warne	53.46±1.15	6.63±0.82	12.40±0.80
Conqueror	46.32±1.13	8.37±0.79	18.07±0.92
Orinoco	41.36±1.24	9.17±0.87	22.17±2.32

TABLE 9.—*Frequency distribution of width of leaves in five cigarette tobacco varieties raised at Alabang*

Variety name	Class centers for width of leaves in cm								
	8	10	12	14	16	18	20	22	24
North Carolina Bright Yellow	.....	.....	.....	.....	.....	1	1	3	5
Adcock	.....	.....	.....	.....	5	3	6	4	5
Big Warne	.....	.....	.....	.....	.....	.....	1	2	4
Conqueror	.....	.....	.....	2	0	2	5	4	1
Orinoco	6	5	8	4	0	1	1	.....	.....

Variety name	Class centers for width of leaves in cm							Total
	26	28	30	32	34	36	38	
North Carolina Bright Yellow	3	5	3	3	1	.....	.....	25
Adcock	1	1	.....	.....	.....	.....	.....	25
Big Warne	3	3	1	1	.....	.....	.....	15
Conqueror	2	4	4	0	0	0	1	25
Orinoco	.....	.....	.....	.....	.....	.....	.....	.....

Variety name	Mean	Standard deviation	Coefficient of variability
North Carolina Bright Yellow	26.44±0.55	4.07±0.37	15.39±0.77
Adcock	20.64±0.45	3.31±0.32	16.04±0.80
Big Warne	25.60±0.54	3.08±0.38	12.03±0.76
Conqueror	23.92±0.75	5.57±0.53	23.28±1.23
Orinoco	11.52±0.40	2.98±0.28	25.86±1.40

TABLE 10.—*Frequency distribution of number of standard leaves, height of plants, and length and width of leaves of the Adcock variety grown in Maligaya, Nueva Ecija.*

A. NUMBER OF STANDARD LEAVES

Class centers (cm)	16	18	20	22	24	26	28	30	32	34	Total
Frequency distribution........	2	2	18	12	5	3	3	2	3	.....	50

Mean	Standard deviation	Coefficient of variability
22.6±0.37	3.88±0.26	16.9±0.60

B. HEIGHT OF PLANTS

Class centers (cm)	120	125	130	135	140	145	150	155	160	Total
Frequency distribution............	5	6	3	9	12	6	5	1	3	50

Mean	Standard deviation	Coefficient of variability
137.8±1.01	10.66±0.72	7.74±0.26

C. LENGTH OF LEAVES

Class centers (cm)	30	32	34	36	38	40	42	44	46	48	Total
Frequency distribution........	2	2	10	6	3	9	4	11	2	1	50

Mean	Standard deviation	Coefficient of variability
38.92±0.43	4.60±0.31	11.81±0.41

D. WIDTH OF LEAVES

Class centers (cm)	16	18	20	22	24	26	28	Total
Frequency distribution..............	5	8	13	8	10	4	2	50

Mean	Standard deviation	Coefficient of variability
21.20±0.30	3.17±0.21	24.95±0.89

ILLUSTRATIONS

PLATE I

FIG. 1. Various steps in the preparation of the seed beds.
2. Seed beds with cogon cover completed.

PLATE II

FIG. 1. Method of poling the leaves preparatory to curing. The arrangement of the leaves in the string is face to face and back to back.
2. Method of curing the leaves in the sun. The nipa cover at the left is used for covering the leaves in case of rain and dew.

PLATE III

FIG. 1. The Adcock tobacco variety; a typical plant.
2. The North Carolina Bright Yellow tobacco variety; a typical plant.

PLATE IV

FIG. 1. The Big Warne tobacco variety; a typical plant.
2. The Conqueror tobacco variety; a typical plant.

1

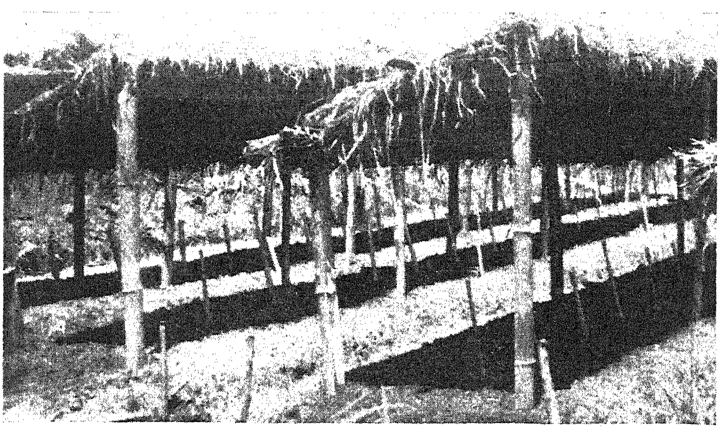

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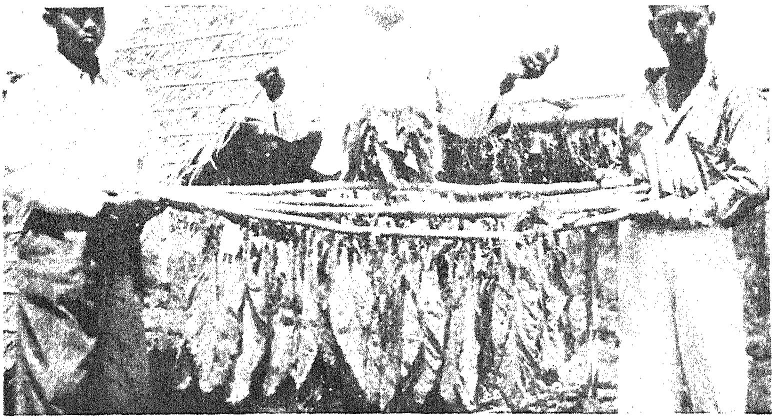
PLATE I



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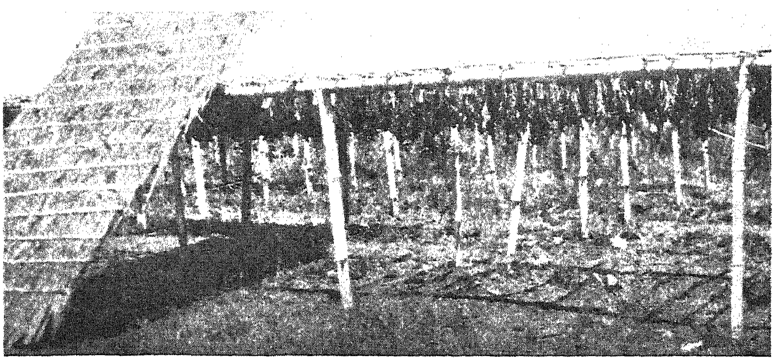

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PLATE II

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PLATE III

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2

PLATE IV

STUDIES ON IRISH POTATOES AT THE BAGUIO SEMI-TEMPERATE FRUIT STATION, MOUNTAIN PROVINCE, LUZON, 1930–1932

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ONE PLATE

This paper is partly a continuation of two separate articles previously published by the writer.[1] It was considered necessary to prepare this report for two reasons: First, the research work started by the writer at the Baguio Semi-temperate Station was discontinued because of his transfer to the Central Office to take charge of vegetable research and therefore the getting of more data to corroborate what has already been obtained may not be possible for some time; and second, to make the data so far obtained available to the public, thus meeting the need for more information on Irish potato culture in the Philippines.

The studies that were undertaken consisted of the following:

I. Potato production as affected by date of planting, 1930–1932.
II. The effect of commercial fertilizers on potato production, 1930–1932.
III. Variety test on Irish potatoes, 1931–1932.
IV. A preliminary study on the storing of the potato tubers for seeds; and on its yielding power, 1931–1932.

The first two experiments were run for a period of two years, and the last two were for a year only. The stand and production of the crops during the 1931–1932 cropping season were, in general, better than those of 1930–1931. This was mainly due to the use of Bordeaux mixture spray to control potato blights, and partly because of a better field knowledge of the culture of the crop.

I. POTATO PRODUCTION AS AFFECTED BY DATE OF PLANTING

As already reported,[2] the object of the study was to determine the best time to plant Irish potatoes in Trinidad Valley, Mountain Province. In the first test, four sets of plantings were

[1] Philip. Journ. Agr. 3 (1932) 39–47 and 49–57. [2] T. c. 39–47.

made, and each set was replicated nine times. In the second test, there were five sets of plantings, and each set was replicated eight times. All the plots were fertilized with guano and a commercial fertilizer (16.5–16.5–21.5) at the rate of 400 kilos of each to a hectare. The plots were also irrigated whenever necessary, which was not the case in the first test.

Table 1 presents a summary of the results of the second test (1931–1932); Table 2 is a summary of the results for the two years.

TABLE 1.—*Showing the average yield of a 25-square meter plot as affected by date of planting 1931–1932*

Date of planting	Yield of tubers per plot		Difference between two plantings on yield of marketable tubers	Significance of difference
	Total	Marketable		
	Kilos	*Kilos*	*Kilos*	
November 2, 1931	10.00±0.46	9.10±0.44	....	
November 18, 1931	13.20±0.48	11.60±0.45	2.50±0.63	Significant.
December 15, 1931	18.80±1.12	18.20±1.27	6.60±1.35	Do.
January 15, 1932	19.60±1.12	18.90±1.06	0.70±1.65	Insignificant.
January 18, 1932	16.50±0.66	15.70±0.66	—3.20±1.25	Slightly significant.

TABLE 2.—*Showing the effect of date of planting on the yield of marketable tubers per hectare*

Date of planting	Yield of marketable tuber per hectare			
	1930–1931 test [a]		1931–1932 test	
	Kilos	Relative	Kilos	Relative
		Per cent		*Per cent*
November 2	....	....	3,640	100
November 15	736	100	4,640	128
December 15	3,000	408	7,280	200
January 15	2,440	345	7,560	205
February 15	1,440	196	6,280	173

[a] This test plot was not fertilized nor was it sprayed with Bordeaux mixture.

It will be seen in Table 1 that the December 15 and January 15 plantings gave the highest average yields both in the total and marketable tubers. In the 1930–1931 test, the December 15 planting gave a slightly greater production,[3] but in the 1931–1932 test, the January 15 planting was slightly better in yield. In both cases, however, the difference was mathematically insignificant. The February 18 planting was the third best, and followed by the November 15 planting. The early planting (November 2) was the poorest. This was due, perhaps, to the greater amount of rainfall that occurred during the life of the plants.

[3] Loc. cit.

The best yields of marketable tubers in the 1931–1932 season were obtained from those planted December 15 and January 15; they gave an average yield of 7,280 and 7,560 kilos, respectively, per hectare. In the light of the two years' results, the best time to plant potatoes in Trinidad Valley and in Baguio, Mountain Province, is about December 15 to January 15.

II. THE EFFECT OF COMMERCIAL FERTILIZERS ON POTATO PRODUCTION

This study was conducted for two years, and the plan of the work was the same as previously reported.[4] The fertilizer (9–12–9) was applied at three rates, and each rate was replicated ten times. The application was made a day previous to planting, and the furrow system was employed. The plants were liberally irrigated and sprayed with Bordeaux mixture. The plots were cultivated and weeded as uniformly as was possible.

In the 1931–1932 test, a representative sample of the marketable tubers from each treatment was weighed to determine the average weight of each tuber. In this way one could get some idea as to whether the increase in yield brought about by the application of fertilizers was due to the increase in the size of the tubers or due to the increase in the number of tubers produced per plant.

Table 3 presents a summary of the 1931–1932 test and Table 4, is a summary of the 1930–1931 and 1931–1932 tests.

TABLE 3.—*Showing the actual yield of 25-square meter plots of Irish potatoes and the size of marketable tubers as affected by the amount of fertilizer (9–12–9) applied.*

Plot No.	Rate of application per hectare							
	Check		200 kilos		450 kilos		700 kilos	
	Total	Marketable	Total	Marketable	Total	Marketable	Total	Marketable
	Kilos	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*
1	13.2	12.8	18.0	17.5	21.4	20.7	22.4	21.6
2	10.8	10.5	15.4	15.1	19.0	18.6	21.4	20.7
3	12.2	11.9	17.4	16.7	21.2	20.5	21.8	21.3
4	10.2	9.9	13.6	13.2	15.6	15.0	18.4	17.9
5	11.0	10.7	20.4	19.7	18.2	17.6	18.0	17.4
6	10.0	9.7	17.7	17.1	17.0	16.6	20.8	20.0
7	10.8	10.2	14.4	13.7	23.4	22.3	21.4	20.6
8	9.4	9.0	14.8	14.2	17.6	16.9	21.2	20.4
9	10.8	10.4	17.0	16.2	21.4	20.9	23.5	22.7
10	11.7	11.3	14.4	13.8	19.8	19.1	23.3	22.8
Average	11.00	10.60	16.30	15.70	19.50	18.80	21.20	20.50
Probable error	±0.27	±0.22	±0.44	±0.42	±0.49	±0.47	±0.37	±0.36
Average weight of 100 tubers....grams	64.3±1.62		70.8±1.93		80.9±2.40		87.5±2.77	

[4] T. c. 49–57.

TABLE 4.—*Comparative yields of 25-square meter plots of potatoes as affected by different amouts of a 9-12-9 fertilizer.*

Rate of application per hectare	Average total yield per plot	Increase over check	Significance of difference	Average marketable tubers per plot	Increase over check	Significance of difference
Kilos	*Kilos*	*Kilos*		*Kilos*	*Kilos*	
Check	11.0±0.27	....	....	10.6±0.22	....	....
200	16.3±0.44	5.3±0.52	Significant..	15.7±0.42	5.1±0.47	Significant.
450	19.5±0.49	8.5±0.56	.....do.....	18.8±0.47	8.2±0.52	Do.
700	21.2±0.37	10.2±0.46	.....do.....	20.5±0.36	9.9±0.42	Do.

TABLE 5.—*Showing the yield of Irish potatoes as affected by the amount of fertilizer (9-12-9) applied.*

Rate of application per hectare	Marketable tubers only					
	1930–1931 test		1931–1932 test		Average	
	Kilos	Relative	Kilos	Relative	Kilos	Relative
Kilos		*Per cent*		*Per cent*		*Per cent*
Check	2,136	100	4,240	100	3,188	100
200	3,120	126	6,280	145	4,700	136
450	4,208	173	7,520	175	5,864	174
700	4,560	187	8,200	190	6,380	189

The effect of fertilizers on growth.—No apparent fertilizer injury was noted, as in the 1930–1931 test, perhaps, due to the liberal supply of irrigation water during the early growing period of the plants. The effect of the fertilizers applied was readily noticeable soon after the shoots began to appear above ground. The plants in the fertilized plots were stout, dark green, and had vigorous growth.

The effect of fertilizers on production.—As seen in Tables 3 and 4, the fertilized plots gave greater average yields than the check plots, and as in the 1930–1931 test,[5] the increases in yields, of both total and marketable tubers, over the check plots were decidedly significant (Table 4).

Comparing the average yields of the plots receiving different amounts of fertilizers, it will be seen in Table 4 that the increase in yield was more or less proportional to the amount of fertilizers applied. The plots fertilized at the rate of 200 kilos per hectare gave an average total yield of 16.3 ± 0.44 kilos, and 15.7 ± 0.42 kilos of marketable tubers. The plots receiving 450 kilos per hectare, on the other hand, gave an average total yield of 19.5 ± 0.49 kilos, and 18.8 ± 0.47 kilos of marketable tubers, giving an increase over the 200-kilo rate per hectare of 3.2 ± 0.65 kilos in average total yield, and 3.1 ± 0.63 kilos in market-

[5] Philip. Journ. Agr. 3 (1932) 49–57.

able tubers. These increases are considered significant. The plots with 700-kilo rate per hectare gave an average total yield of 21.2 ± 0.37 kilos, and 20.5 ± 0.36 kilos of marketable tubers, thus showing an increase of 1.7 ± 0.61 kilos in average total yield, and 1.7 ± 0.59 kilos in marketable tubers over the 450-kilo application per hectare. These increases were only slightly significant. These results, too, corroborate those of the 1930–1931 test.

As seen in Table 5, the average yield in marketable tubers of the check plots in the two-year test was 3,188 kilos per hectare against the 4,700, 5,864, and 6,380 kilos of the plots fertilized at the rate of 200, 450, and 700 kilos per hectare, respectively. In terms of percentage, the corresponding increases over the check plots were 36, 74, and 89 per cent, respectively.

The effect of fertilizer on the size of tubers.—The fertilized plots produced bigger (heavier) tubers than the unfertilized ones (Table 3). There was an apparent tendency for the marketable tubers to be heavier and bigger in the plots which received heavier dressings of fertilizer. This tendency may have been due to the bigger and stouter stems of the plants as a result of vigorous growth brought about by the fertilizer applied.

III. VARIETY TEST

This study had for its object the finding of the best variety for planting in Baguio and in Trinidad Valley, Mountain Province, both in yield and in keeping and eating qualities. At the time this experiment was being carried on, three varieties were more widely grown in the region than others, but due to lack of available seed, only two varieties were included in the test; namely, the Japanese Red and the Japanese White. The Spanish potato, or neutralized potato, in the Mountain Province, that is grown by the natives, was not included.

The study was conducted during the 1931–1932 potato season; the two varieties were planted in 25-square-meter plots and replicated eight times each. As bases of comparison, the following criteria were used: (*a*) number of days to maturity, (*b*) number of shoots per hill, (*c*) number of tubers per hill, (*d*) nature of producing tuber, (*e*) yield per unit area, (*f*) weight of individual marketable tubers, and (*g*) storing and eating quality of tuber. In getting data on the number of shoots per hill, number of tubers per hill, and weight of marketable tubers, 100 determinations each were made at random. Table 6 gives a summary of these studies.

TABLE 6.—*Showing comparative difference in yield, weight of tubers, storing quality, etc., of two potato varieties.*

Character studied	Name of variety		Difference	Significance of difference
	Japanese White	Japanese Red		
	Kilos	*Kilos*	*Kilos*	
Average total yield per 25-square-meter plot.	28.2 ± 1.61	37.7 ± 1.32	6.5 ± 2.08	Slightly significant.
Average marketable tuber per 25-square-meter plot	27.1 ± 1.61	33.4 ± 1.30	6.3 ± 2.07	Do.
Average weight of individual tubers in grams.	82.5 ± 3.00	149.7 ± 5.91	67.2 ± 6.63	Significant.
Average number of shoots per hill	2.8 ± 0.07	1.1 ± 0.03	1.7 ± 0.07	Do.
Average number of tubers per hill	6.2 ± 0.20	3.3 ± 0.11	2.9 ± 0.23	Do.
Percentage rotten when stored for four months	0.5 ± 0.23	14.2 ± 1.33	13.7 ± 1.35	Do.

Of the two varieties tested, the Japanese Red was the later in maturing; it matured twelve days later than the Japanese White, which matured in eighty-nine days after planting. The Japanese White, as its name indicates, has white skinned tubers, round to elliptical in shape with shallow eyes, while the Jananese Red has light red skin, round or spherical tubers with comparatively shallow eyes. The tubers in the case of the Japanese White were formed or clustered together close to the base of the plant while in the case of the Japanese Red, many of the tubers were formed or located several centimeters away from the stem (see fig. 1); this behavior is especially true when the soil is friable. This characteristic of the variety must be considered in time of cultivation; the plow or cultivator should not come within the 20-centimeter limit from the base of the plant in the case of the Japanese Red so as not to destroy the developing tubers.

The Japanese White had decidedly more shoots and tubers per hill than the Japanese Red. The number of shoots per hill of the Japanese White was 2.8 ± 0.07 against 1.1 ± 0.03 of the Japanese Red, and 6.2 ± 0.20 tubers per hill of the Japanese White against 3.3 ± 0.11 for the Japanese Red. On the other hand, the Japanese Red had decidedly bigger tubers, the average weight of a marketable tuber being 149.7 ± 5.91 grams against 82.5 ± 3.00 grams for the Japanese White. The fact that the Japanese Red had fewer tubers per hill and that the tubers were not crowded at the base of the plants as in the case of the Japanese White, may account for the bigger tubers of the former. In yield per unit area, the Japanese Red was slightly better. The production of a 25-square-meter plot was 28.2 ± 1.61 kilos in average total yield, and 27.1 ± 1.61 kilos in marketable tubers for the Japanese White, while the corresponding yield in the

case of the Japanese Red were 34.7 ± 1.32 and 33.4 ± 1.30 kilos, respectively. The differences in both cases, however, are considered only slightly significant (see Table 6).

Tests on the storing and eating qualities of the two varieties showed that the Japanese White was far superior to the Japanese Red. When the tubers were stored in crates in an ordinary room for about three months a few weeks after digging of the Japanese White only 0.5 per cent became rotten or partly so, while 14.2 per cent of the Japanese Red decayed. As to eating quality, the Japanese White was also superior; it had a better taste and was firmer in texture. The Japanese Red was rather friable and watery when cooked, especially so the big tubers.

IV. STORING OF BAGUIO-GROWN POTATOES FOR SEED AND ITS VALUE AS SUCH

At the present time, the seed is a big item of expense in connection with the growing of Irish potatoes in the Philippines. To make potato growing a paying industry, the seed should be locally produced. It was because of the desire to solve this particular problem that a preliminary study in the storing of Philippine grown potatoes for seed purposes was started. Part of the harvest of the 1930–1931 crop of the Baguio Semi-Temperate Fruit Station was used as material for the study. Two crates of selected tubers of the Japanese White were used. One crate was buried under one of the houses at the Baguio Semi-temperate Fruit Station to a depth of 1 foot (30 centimeters) from the top of the crate to the surface of the ground. The soil in this place remained comparatively dry until about September when it got wet because of a storm. The other crate was stored in the office. The period of storage lasted for four months—from June to September, 1931. It was decided to determine the storing test in September so as to save some tubers for planting purposes.

At the close of the storing test, the two sets of seed potatoes were examined and the number of germinated tubers counted, and so with those that were rotten. The tubers stored in an ordinary room and those buried under a house had all germinated; they produced long and slender shoots. Those stored in the office became badly shriveled and were very soft, while those buried were still hard and smooth.

Selected seed potatoes from both sets of tubers were planted side by side with fresh seed from Japan of the same variety. Table 7 presents a summary of this study.

TABLE 7.—*Showing the performance of Baguio-grown Japanese White potatoes compared with imported seed of the same variety*

Description of seed used	Germination	Yield per 25-square meter plot: Total yield — Weight	Total yield — Difference	Significance of difference
	Per cent	*Kilo*	*Kilo*	
Imported seed from Japan (control)	96.1	14.9±0.64	....	....
Baguio-grown (crated and stored in a room)	69.0	3.4±0.36	—11.5±0.73	Significant.
Baguio-grown (crated and buried under a building)	69.1	4.9±0.28	—10.0±0.70	Do.

Description of seed used	Germination	Marketable tuber — Weight	Marketable tuber — Difference	Significance of difference
	Per cent	*Kilo*	*Kilo*	
Imported seed from Japan (control)	96.1	13.5±0.60	....	....
Baguio-grown (crated and stored in a room)	69.0	2.4±0.25	—11.1±0.65	Significant.
Baguio-grown (crated and buried under a building)	69.1	3.5±0.20	—10.0±0.63	Do.

The methods of storing seed potatoes that were employed, namely, (*a*) in crates in an ordinary room, and (*b*) in crates buried under a building, were not found satisfactory under Baguio conditions even for a period of four months only. In the former method, the tubers germinated and produced long, slender shoots, and the tubers themselves became shriveled and very soft. In the second method, all the tubers also produced too long shoots, though they remained hard and seemed fairly suitable for planting purposes.

As seen in Table 7, the seed-tubers stored under both methods were very much inferior to the imported seed of the same variety. The percentage of germination was very low, and even most of those that germinated produced weak plants. It may be remarked in passing, however, that there were a few plants from the Baguio-grown seed that were comparable to the best from the imported seed. So that it may yet be assumed that the inferior producing power of the Baguio seed was mainly due to the fact that it was greatly devitalized because of early germination in storage long before the planting season. So as not to have to store for long periods, some studies are now being undertaken in parts of the Islands where the climatic conditions are favorable to the growing of potatoes during the month of June and July, to produce seed tubers during the general planting season in November to February. Recent reports give the information that a good potato crop has been obtained at Panubigan, Occidental Negros, from a trial made in July, 1933.

Of the two methods of storing employed, burying the seed-tubers in dry ground under a building was better than storing in an ordinary room. The plants obtained from the former set of seed were stouter and yielded about 46 per cent more than the latter.

SUMMARY OF CONCLUSIONS

From the results presented in this paper, the following conclusions seem justified:

1. The best time to plant Irish potatoes in Baguio and in Trinidad Valley, Mountain Province, is between December 15 and January 15. Provided adequate irrigation water is available, a fair crop can be obtained by planting as late as February 15.

2. All the plots treated with a 9–12–9 commercial fertilizer gave greater average yields than the check plots; the increase in yield was more or less proportional to the amount of fertilizers applied. The plots treated at the rate of 450 and 700 kilos per hectare gave an increase of 74 and 89 per cent, respectively, in marketable tubers over the unfertilized plots.

3. The size of the marketable tubers was affected by the amount of fertilizer applied. It was evident that the tendency was towards bigger tubers in plots receiving heavier applications of fertilizer. The average weights of tubers from the different treatments were 64.3 ± 1.62, 70.8 ± 1.93, 80.9 ± 2.40 and 87.5 ± 2.77 grams for the control (unfertilized), and the 200-, 450-, and 700-kilo rate per hectare, respectively.

4. The Japanese Red produced fewer but bigger tubers and yielded slightly more per unit area than the Japanese White. On the other hand, the Japanese White had better keeping and eating qualities than the former. Taking all points together the latter variety (Japanese White) is the better for commercial planting. The superior keeping quality of the Japanese White alone more than offsets the higher yielding power of the Japanese Red.

5. Storing Baguio-grown potatoes for seed in a room or in a pit under a building was not successful. The tubers thus stored germinated long before the planting season, thus they were inescapably devitalized; when they were planted, they were very much inferior to fresh imported seed from Japan in growth and in yielding power. The presence, however, of a few plants that compared favorably in stand and yield with the imported plants showed the potential value of home-grown seed if properly stored.

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ILLUSTRATIONS

PLATE I

FIG. 1. Showing the characteristic arrangement of the tubers at the base of the plants. Japanese White. Note how the tubers are clustered together at the base.

2. Showing the characteristic arrangement of the tubers at the base of the plants. Japanese Red. The tubers are few, and are formed away from the base.

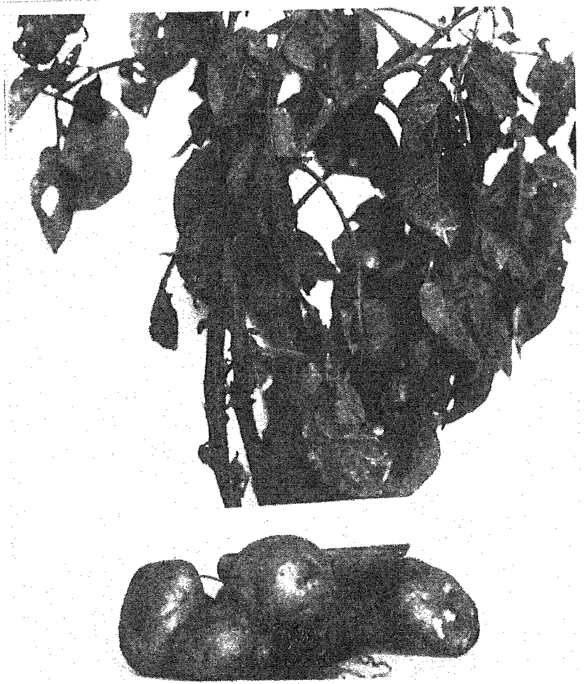

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PLATE I

CHEMICAL CHANGES OCCURRING DURING THE SALTING OF CHICKEN AND DUCK EGGS UNDER DIFFERENT TREATMENTS

By F. T. ADRIANO[1] and T. V. RIGOR[2]

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FOUR TEXT FIGURES

The rôle of salt in the preservation of foods, especially meat and fish products, has been known for a long time. In fact salt was one of the first known materials for preserving meat and fish. In China and in the Philippines, salt is also employed for preserving eggs. While there is no record to show how extensive the salting of eggs is in the Philippines, it must be a thriving business judging from the number of salted duck eggs sold everywhere. Table I, prepared by the Division of Statistics of the Department of Agriculture and Commerce, shows that the Philippines are importing nearly 400,000 dozen preserved eggs from China, a large proportion of which are salted.

Salted duck eggs are commonly sold throughout the Philippines. They are sold at from 2.80 to 2.90 pesos[3] per hundred, while fresh duck eggs are sold at from 2.30 to 2.40 pesos per hundred. Salted eggs are boiled and then dyed magenta, and they usually remain in the stores many days and even weeks before they are sold and eaten; hence, quite frequently one opens an egg and finds it spoiled. Moreover, eggs sold in the stores are not as fine flavored and wholesome as the home-made ones, which can be prepared easily.

Literature on the subject is conspicuous for the absence of reported chemical study of preparing salted eggs. It is the purpose of this paper to report the results of a preliminary study of the chemical changes occurring during the salting of eggs.

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[3] One peso Philippine currency equals 50 cents United States currency.

There are several methods of preserving eggs. Those commonly used in America and Europe are low temperature storage and the exclusion of air by the use of oil and water glass (Na_2SiO_3). The use of salt is extensive in the Orient. In the Philippines the eggs are coated with a clean, sticky clay to which plenty of salt has been added, the commonest proportion being one part of salt to four or five parts of clay. Another method is to place the eggs in a cold saturated solution of table salt. In East India, according to Wang[4] (1929), duck eggs are often preserved by packing them in a mixture of clay, brick-dust, and salt for two or three months. In China several methods of preserving eggs are used. Duck eggs are often buried in the ground for ten to twelve months. Eggs thus preserved undergo a peculiar fermentation. The hydrogen sulphide produced breaks the shell and escapes, while the eggs become hard in texture. The process completed, the product has no disagreeable odor or taste. Eggs are also preserved in a mixture of salt and cooked rice to which wort has been previously added. The eggs are stored for six months or longer, and by the time they are ready for market the shells have been dissolved or completely softened and the inner membrane greatly thickened. The egg is somewhat coagulated. It looks like a soft-boiled egg, but it has a strong winelike taste and smell.

Another kind of preserved eggs found in China is the so-called "hilidan" eggs. The eggs are immersed in a saturated cold solution of common salt and after a month or more they are eaten hard-boiled. In some parts of China a mixture of salt, sea earth or wood ashes, and water is used. The eggs—duck eggs usually—are carefully washed and then covered one by one with this mixture. They are then packed in jars and stored away for about a month. Still another kind of preserved duck egg found in China is the so-called "Pidan," the famous century eggs of China. The method employed in its preparation is as follows: One and one-third pounds of strong black tea is made. Into this infusion, 9 pounds of lime and 4.5 pounds of common salt are put and finally, about 32 quarts of freshly burned wood ashes is added. The best quality duck eggs are first cleaned and then one by one carefully and evenly covered with the mixture. They are then stored for a period of

[4] Wang, Chi Che, U. S. Egg and Poultry Mag. (October, 1929).

five months. At the end of this period they are taken out and covered fully a quarter of an inch deep with rice hulls. The eggs are then ready for the market.

MATERIALS AND METHODS

Fresh chicken and duck eggs were used in this study. Forty chicken eggs were placed in a 10 per cent salt (NaCl) solution and another 40 were placed in a saturated salt solution. Five eggs in the fresh state were boiled hard, separated into the different parts (shell, white, and yolk) and each part was weighed and sampled for analysis. These served as the control. Every five days, five eggs were taken from each lot. The eggs were then weighed, separated into the different parts in the same way as just described, sampled, and analyzed.

Fresh duck eggs were also used, but in place of the 10 per cent salt solution a soil-salt mixture of equal parts by volume of air-dried soil from a termite hill or mound and salt were used. After the soil and salt were thoroughly mixed, a sufficient amount of water was added to form a thick paste. The duck eggs, which had been well washed, were placed in this soil-salt paste. Ten duck eggs were analyzed for control. Every five days, ten eggs were taken from each lot and analyzed in the same way as the chicken eggs.

METHODS OF ANALYSIS

The samples (shell, white or albumen, and yolk) were analyzed for moisture, ash, and sodium chloride by the methods adopted by the Association of Official Agricultural Chemists (1925).

RESULTS AND DISCUSSIONS

The results of this study are given in Tables 2 to 7 and text figs. 1 to 4.

The behavior of the eggs under the different treatments did not vary greatly. Examination of the tables and graphs will show, for example, that the percentage of shell in the egg tended to increase somewhat, but not greatly. The apparent increase in the percentage of shell in the egg seems to have been due to the changes in moisture and sodium chloride content. In the case of chicken eggs, for example, there was a drop of moisture in the first week. Thereafter, with eggs treated in saturated brine,

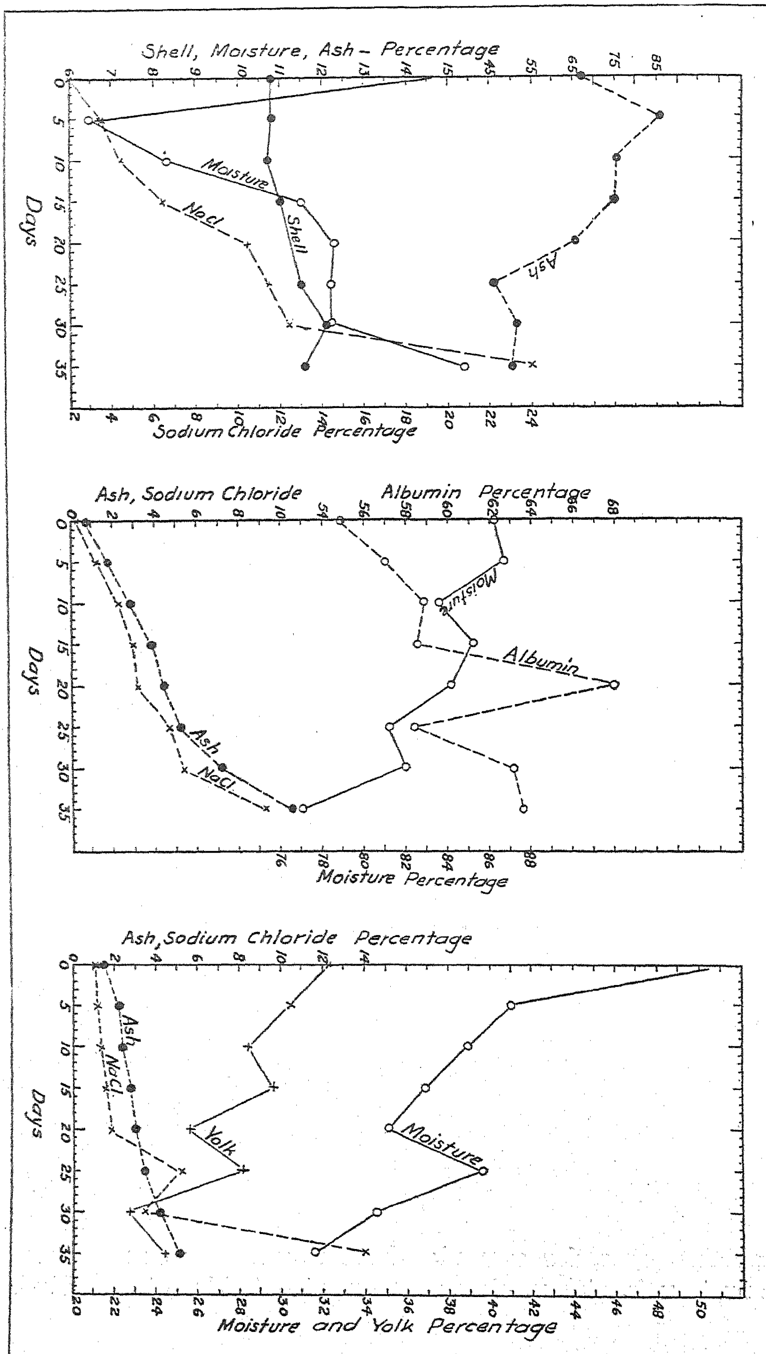

FIG. 1. Chemical changes in chicken eggs during salting in saturated salt solution

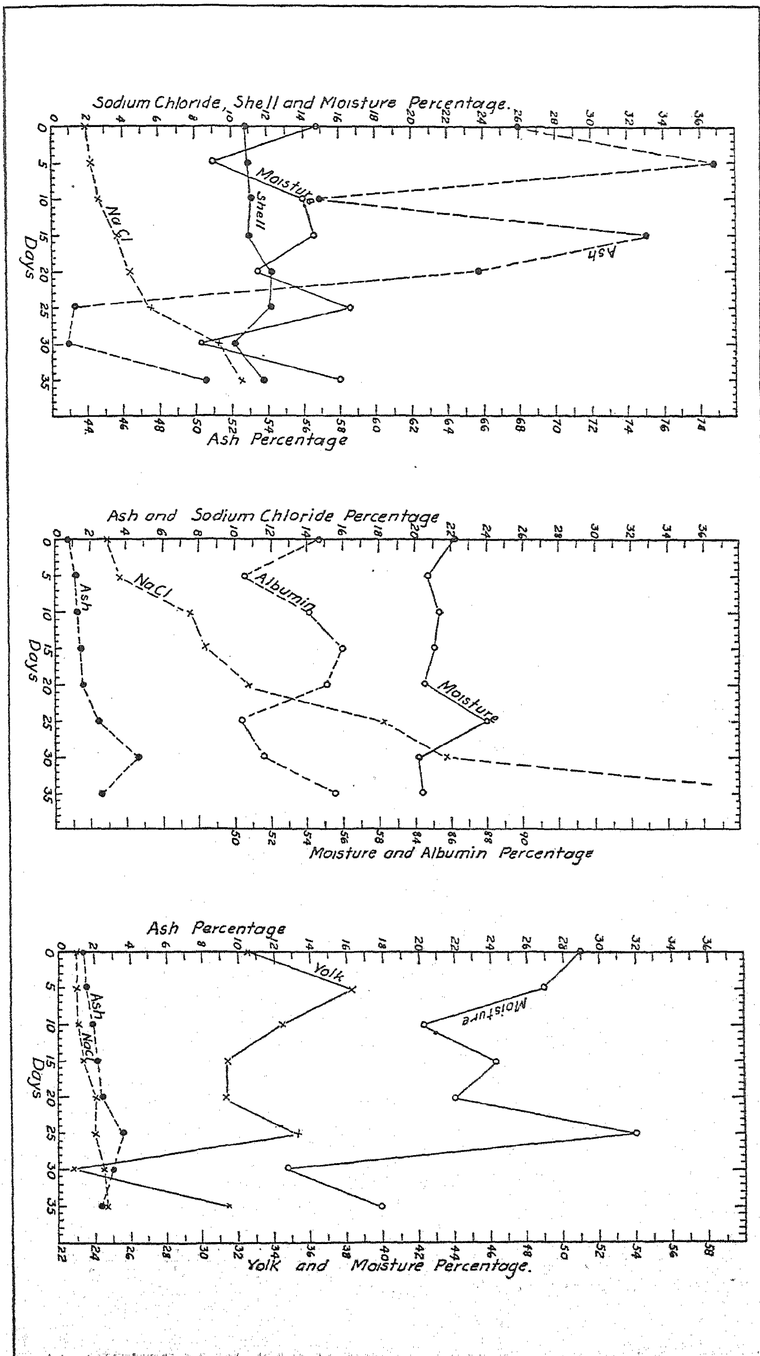

FIG. 2. Chemical changes in chicken eggs during salting in 10 per cent salt solution

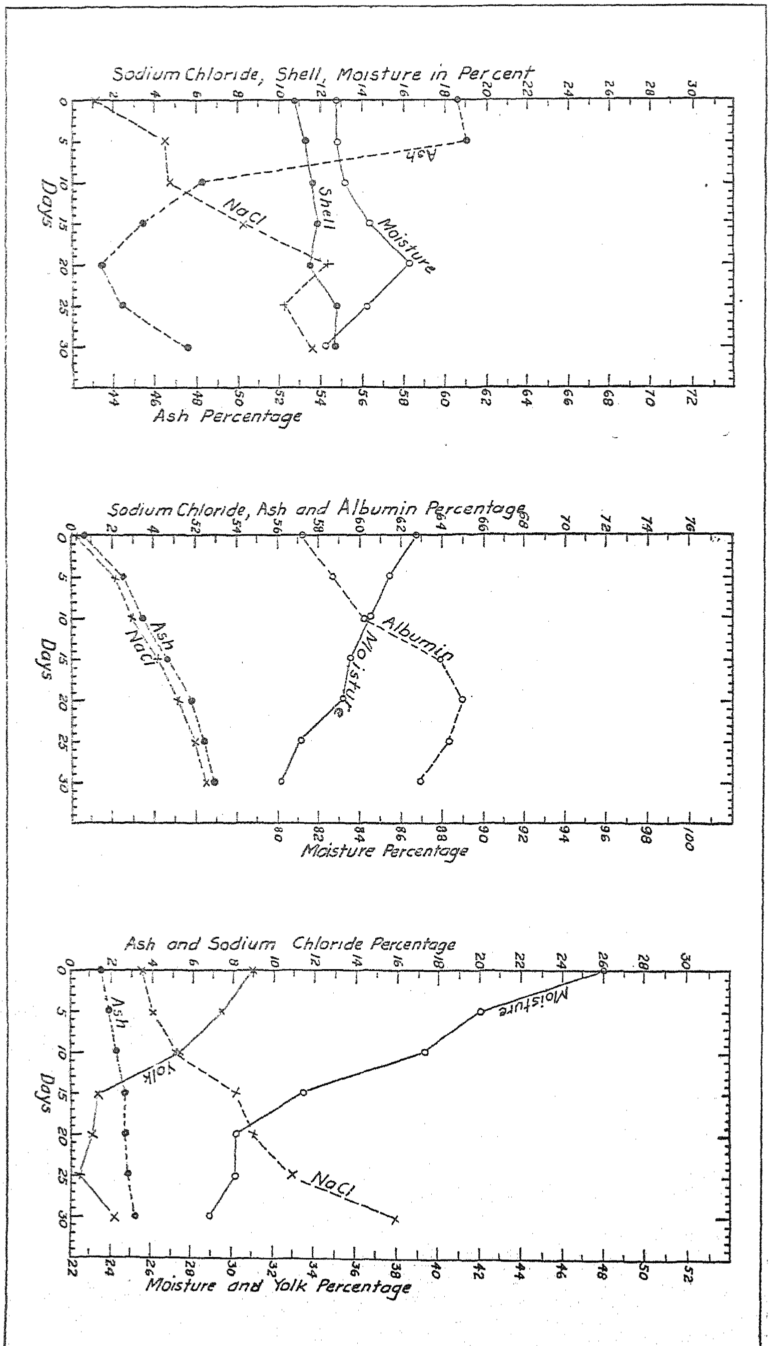

FIG. 3. Chemical changes in duck eggs during salting in saturated salt solution.

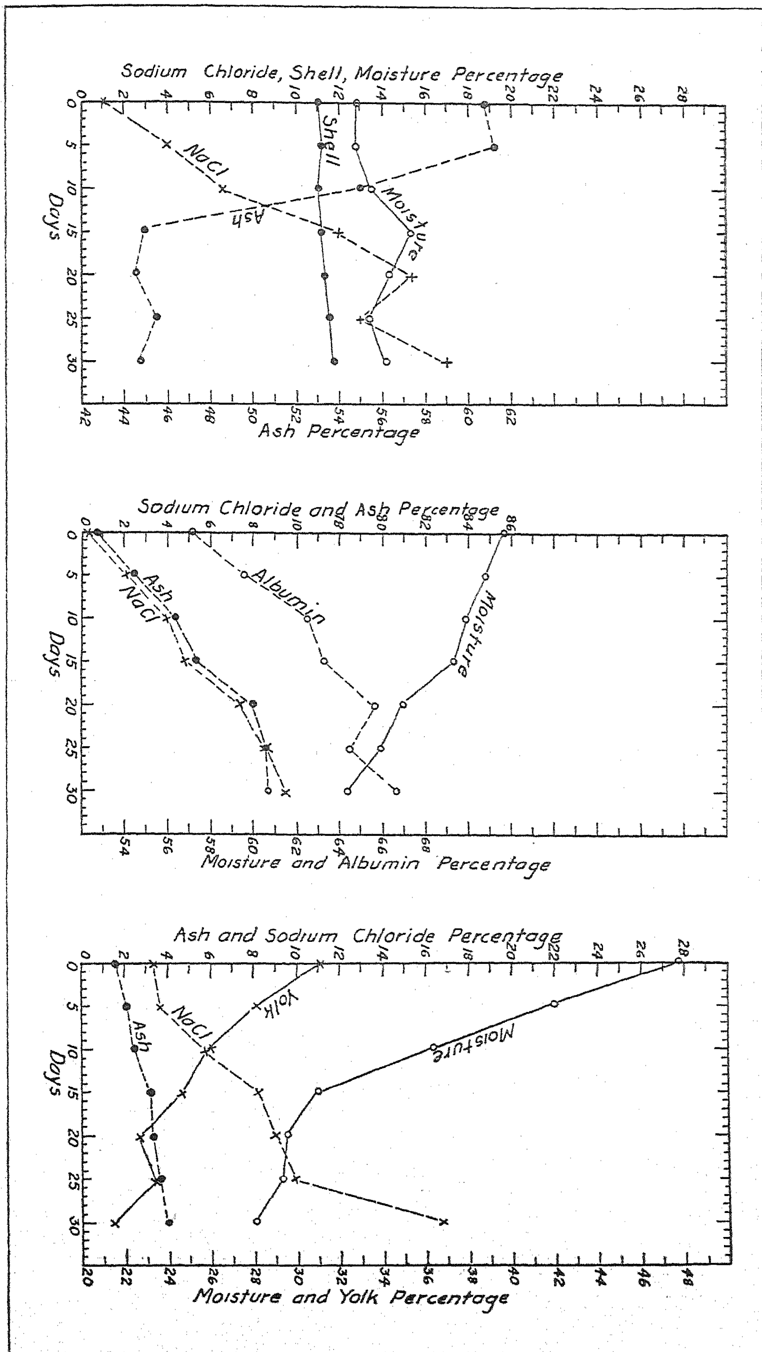

FIG. 4. Chemical changes in duck eggs during salting in soil-salt mixture

there was an increase of moisture above the initial value (Table 2 and text fig. 1). The moisture of shell in chicken eggs treated with a 10 per cent salt solution showed an uneven behavior, but the tendency was also towards an increase. With duck eggs, the increase in moisture continued until the second and fourth weeks, after which the moisture content dropped.

In all cases, the sodium chloride content of the shell increased. This increase may have been due to the absorption of sodium chloride by the shell. Thus it will be seen that in all cases the ash content of the shell increased during the first five days, due to the incorporation of sodium chloride in the shell, then decreased greatly thereafter until the twentieth or twenty-fifth day, after which there was a tendency to increase again.

There was an increase in the percentage of albumin in the egg in the chicken and duck eggs treated with saturated salt solution, and in duck eggs preserved in soil-salt mixture. With the chicken eggs in 10 per cent salt solution, the albumen in the eggs varied between 50 and 56 per cent, but the initial and final values were almost the same, about 55 per cent. In the first three cases the increase in albumen in the eggs was evidently due to the absorption of salt by the albumen portion, as shown by a steady increase in the sodium chloride content and also by the consistent increase in ash, paralleling the increase in sodium chloride. The incorporation of sodium chloride in the albumen decreased the relative proportion of moisture in the albumen. With the chicken eggs treated with a 10 per cent salt solution, there was an unusual increase in sodium chloride, possibly due to the effect of dilution. The increase in salt increased the percentage of ash in the albumen. The increase in salt in the albumen in chicken eggs in saturated salt and duck eggs in saturated salt and soil-salt mixture was from 5 to 10 per cent, while that in chicken eggs in a 10 per cent salt solution was about 40 per cent.

It may be seen that, in all cases, the percentage of yolk in the eggs decreased. It may also be seen that the decrease in yolk in the eggs may have been due to the loss in moisture in the yolk, the curves representing the loss in yolk and moisture in the yolk as parallel to each other. In this manner, the preserving media may be thought of as a dehydrating agent, withdrawing moisture from both the albumen and yolk, and apparently from the shell also.

In the case of the chicken eggs, there was an increase in the ash. In the case of the duck eggs, however, the increase in the sodium chloride was very much greater than the increase in the ash for the same period. During the same period the duck eggs absorbed more salt from a surrounding salt solution than chicken eggs. This may explain why duck eggs are generally used for preparing salted eggs.

Regarding the proximate chemical composition of treated duck eggs, it may be seen from Tables 5 and 7 that the percentage of protein of the albumen did not show conspicuous changes and the gain in ash was approximately equal to the loss in moisture.

In the yolk, the total gain in percentage of protein, crude fats, and ash seemed to be nearly equal to and compensate for the loss in moisture. There seemed to be no material change in food value, excepting that the decrease in moisture produces a concentration of these food constituents.

In general it may be seen that although the shell did not change under the various treatments, the sodium chloride of the shell increased as treatment was prolonged, while the ash of the shell decreased to and remained at a certain value. The increase in the sodium chloride and ash content of the albumen was roughly proportional to the duration of treatment. The yolk lost moisture and weight but gained in sodium chloride and ash.

SUMMARY

1. To find the chemical changes occurring during the salting of eggs, fresh chicken eggs were treated with saturated and 10 per cent salt solutions, and duck eggs with saturated salt solution and soil-salt mixture. Periodic analyses of representative samples were made.

2. The percentage of shell in the treated eggs remained more or less constant, the percentage of albumen increased and the percentage of yolk decreased.

3. There was an increase of sodium chloride in the shell, the albumen, and the yolk and an increase of ash in the albumen and the yolk, but a decrease of ash in the shell.

4. The absorption of salt by the yolk was more pronounced in the duck eggs than in the chicken eggs.

5. There was relatively no change in the protein and fat content of both the albumen and yolk, the apparent increases being due to a relative decrease in moisture.

TABLE 1.—*Annual imports of eggs into the Philippines by countries of origin*

Countries of origin	1931		1932	
	Dozens	Pesos	Dozens	Pesos
Eggs in natural form:				
Hen—[a]				
United States	13,797	7,811	15,799	9,007
China	4,780,467	886,170	4,330,333	634,968
British East Indies	31	8	....	....
Japan	145,674	59,686	156,922	33,654
Australia	330	179	....	....
Total	4,940,299	953,854	4,503,054	677,629
Other fresh eggs—[a]				
British East Indies	6,432	383	15,475	778
Preserved eggs—[a]				
China	404,458	96,484	334,278	64,212

[a] Not separately classified prior to 1931.

TABLE 2.—*The chemical changes occurring during the salting of chicken eggs in saturated salt solution*

Treatment	Shell				Albumen				Yolk			
	Shell	Moisture	Ash	Na Cl	Albumen	Moisture	Ash	Na Cl	Yolk	Moisture	Ash	Na Cl
	P. ct.	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*
Untreated	10.85	14.88	68.02	203	54.93	86.26	0.75	304	32.25	50.99	1.49	111
After 5 days	10.89	6.53	86.08	363	57.05	86.74	1.85	1,154	30.52	41.09	2.18	117
After 10 days	10.71	8.25	76.25	447	58.99	83.62	2.93	2,281	28.44	38.90	2.28	126
After 15 days	11.04	11.54	75.41	654	58.53	85.19	3.92	3,017	29.57	36.92	2.84	162
After 20 days		12.25	66.89	1,051	68.05	84.23	4.36	3,113	25.57	35.25	2.96	176
After 25 days	11.51	12.16	47.38	1,145	58.42	81.23	5.21	4,699	28.22	39.64	3.30	522
After 30 days	12.11	12.18	53.47	1,248	63.22	82.08	7.24	5,360	22.71	34.47	4.11	337
After 35 days	11.58	15.43	50.08	2,413	63.58	77.54	10.63	9,309	24.67	31.67	5.12	1,419

TABLE 3.—*The chemical changes occurring during the salting of chicken eggs in 10 per cent salt solution*

Treatment	Shell				Albumen				Yolk			
	Shell	Moisture	Ash	Na Cl	Albumen	Moisture	Ash	Na Cl	Yolk	Moisture	Ash	Na Cl
	P. ct.	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*
Untreated	10.85	14.88	68.02	203	54.93	86.26	0.75	304	32.25	50.99	1.49	111
After 5 days	11.00	8.99	78.79	229	50.56	84.71	1.23	368	38.38	48.97	1.57	114
After 10 days	11.05	14.25	56.98	270	54.16	85.35	1.26	760	34.40	42.25	2.09	122
After 15 days	11.04	14.68	75.05	371	56.08	85.24	1.42	846	31.48	46.26	2.23	146
After 20 days	12.30	11.53	65.75	444	55.18	84.59	1.62	1,082	31.47	43.87	2.46	218
After 25 days	12.16	16.56	43.38	561	50.43	87.95	2.47	1,828	35.27	54.02	3.56	211
After 30 days	10.11	8.29	43.00	929	51.59	84.23	4.65	2,179	22.88	34.79	3.20	264
After 35 days	11.82	16.08	50.58	1,059	55.73	84.28	2.65	4,060	31.52	40.00	2.44	271

TABLE 4.—*The chemical changes occurring during the salting of duck eggs in saturated salt solution*

Treatment	Shell				Albumen				Yolk			
	Shell	Moisture	Ash	Na Cl	Albumen	Moisture	Ash	Na Cl	Yolk	Moisture	Ash	Na Cl
	P. ct.	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*
Untreated	10.92	12.87	60.68	119	57.17	86.76	0.66	428	31.13	47.85	1.50	346
After 5 days	11.22	12.87	60.98	447	58.71	85.50	2.46	2,265	29.47	41.96	1.80	388
After 10 days	11.56	13.08	48.28	470	60.30	84.60	3.48	3,852	27.41	39.39	2.21	510
After 15 days	11.85	14.42	45.38	830	64.01	83.67	4.68	4,151	23.28	33.53	2.76	823
After 20 days	11.48	16.31	43.40	1,245	65.11	83.30	5.75	5,177	23.14	30.15	2.75	887
After 25 days	12.91	14.20	44.43	1,025	64.41	81.12	6.42	5,898	22.43	30.15	2.68	1,104
After 30 days	12.71	12.14	47.63	1,160	62.96	80.32	6.90	6,504	24.13	29.09	3.11	1,607

TABLE 5.—*The chemical changes occurring during the salting of duck eggs in saturated salt solution*

Treatment	Albumen				Yolk			
	Moisture	Protein N x 6.25	Fat-ether extract	Ash	Moisture	Protein N x 6.25	Fat-ether extract	Ash
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Untreated	86.76	11.05	Trace	0.66	47.85	16.95	32.04	1.50
After 5 days	85.50	10.50	do.	2.46	41.96	18.36	36.12	1.80
After 10 days	84.64	11.06	do.	3.48	39.39	18.72	40.15	2.21
After 15 days	83.67	10.45	do.	4.68	33.53	20.44	43.28	2.76
After 20 days	83.30	9.65	do.	5.75	30.15	21.00	46.06	2.75
After 25 days	81.12	10.74	do.	6.42	30.15	19.21	47.00	2.68
After 30 days	80.32	10.00	do.	6.90	29.09	20.98	46.79	3.11

TABLE 6.—*The chemical changes occurring during the salting of duck eggs in soil-salt mixture*

Treatment	Shell				Albumen				Yolk			
	Shell	Moisture	Ash	Na Cl	Albumen	Moisture	Ash	Na Cl	Yolk	Moisture	Ash	Na Cl
	P. ct.	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*
Untreated	10.92	12.87	60.68	119	57.17	86.76	0.66	428	31.13	47.85	1.50	346
After 5 days	11.19	12.83	61.30	389	59.66	84.95	2.54	2,233	28.24	41.85	2.11	371
After 10 days	11.06	13.47	55.02	656	62.74	84.04	4.35	4,139	25.87	36.39	2.38	580
After 15 days	11.19	15.26	44.85	1,203	63.29	83.52	5.39	4,976	24.79	31.00	3.09	829
After 20 days	11.26	14.38	44.59	1,548	65.68	81.09	8.02	7,380	22.79	29.60	3.28	891
After 25 days	11.48	13.30	45.50	1,305	64.52	79.92	8.49	8,452	23.38	29.44	3.64	1,000
After 30 days	11.73	14.21	44.75	1,750	66.64	78.35	8.73	9,512	21.48	28.03	3.95	1,680

TABLE 7.—*The chemical changes occurring during the salting of duck eggs in soil-salt mixture*

Treatment	Albumen				Yolk			
	Moisture	Protein N x 6.25	Fat-ether extract	Ash	Moisture	Protein N x 6.25	Fat-ether extract	Ash
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Untreated	86.76	11.05	Trace	0.66	47.85	16.95	32.04	1.50
After 5 days	84.95	9.72	do.	2.54	41.85	17.85	36.45	2.11
After 10 days	84.04	10.36	do.	4.35	36.39	20.36	40.24	2.38
After 15 days	83.52	8.82	do.	5.39	31.00	20.39	44.85	3.09
After 20 days	81.09	8.73	do.	8.02	29.60	21.35	45.52	3.28
After 25 days	79.92	9.89	do.	8.49	29.44	21.32	45.43	6.64
After 30 days	78.35	10.93	do.	8.73	28.03	21.53	45.61	3.95

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ILLUSTRATIONS

TEXT FIGURES

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A PROGRESS REPORT ON THE CULTURE OF TURKISH TOBACCO

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ONE PLATE

Turkish tobacco is famous all over the world for its delicate and peculiar aroma. It is also high-priced, and for this reason it is generally used only for blending purposes in the manufacture of the higher-priced brands of cigarettes. It is characteristically small-leafed. Clarke(1) reports that the usable leaf of the Turkish tobacco grown in California ranges from 2 to 10 inches (5 to 25.4 centimeters) in length and from 1 to 6 inches (2.5 to 15.2 centimeters) in width. He states further that this range in size is found on the same plant from the largest leaves at the bottom to the smallest leaves at the top. In fact the leaves are very much smaller than those of Virginia or Philippine tobacco, and the yield is correspondingly small, but this disadvantage is more than offset by the high price it commands in the market. According to the local distributor of a popular brand of cigarettes, first-class Turkish leaf tobacco sells for as much as 40 pesos [1] per kilo.

The present investigation has been conducted to find out the soil and climatic requirements of the Turkish variety Samsoun Bafra, to study its cultural requirements, and to determine how

[1] One peso Philippine currency equals 50 cents United States currency.

Philippine-grown Turkish tobacco will compare with tobacco from other countries.

The investigations were conducted principally at Alabang, in Rizal Province, and Muñoz, in Nueva Ecija Province, from October, 1932, to April, 1933. Trial plantings were also made at Sucat, in Rizal, and at Gagalañgin, a barrio of Manila.

PLAN OF THE WORK AT ALABANG, RIZAL

Sowing of seed and care of seedlings.—The seed was sown October 8, 1932, in well-pulverized soil, at the rate of 1 gram for every square meter of seed bed. The seed beds were provided with a portable cover. When the seedlings had about two pairs of leaves they were thinned and pricked, so as to be about 5 centimeters apart.

Land preparation.—The soil is a heavy clay-loam. It is hard when dry and very sticky when wet. The land was plowed and harrowed twice with a tractor before it was planted. Furrows 80 centimeters apart were made with a native plow. As the soil was quite hard, holes 70 centimeters apart were dug to a sufficient depth along the furrows with a native hoe.

Transplanting.—The seedlings were transplanted to the field December 8, 1932. They should have been transplanted several days earlier, but the torrential rains at the time rendered the soil too sticky to be worked. The seedlings were set in the holes by pressing the soil down gently around the base of the plant.

Cultivation.—When the seedlings were well established in the soil the first cultivation was done by breaking the soil particles around the base of the plants with garden hoes. A week later the plow was passed twice between the rows. The process was repeated at regular intervals of two weeks until the plants were too big for the operation.

Control of insect pests and diseases.—In combating the tobacco worms occasional applications of calcium arsenate powder mixed with fine road dust, 1:16 by volume, were made. This treatment was supplemented by picking the worms by hand. The stem-borer, which was abundant in the field, was prevented from further spreading by destroying all the attacked plants. In like manner all the plants that showed symptoms of mosaic and root-rot diseases were removed from the field as fast as they were noticed.

Topping.—In order to determine the effect of topping on the yield and color of the leaves some experiments were performed.

Topping was done in four ways; namely, (*a*) cutting off the bud before the flower head appeared, (*b*) removing the flower head as soon as it appeared, (*c*) cutting off the flower head as soon as the flowers opened, and (*d*) trimming off the flower head as soon as the capsules were formed.

Five rows of one hundred plants each were used for each treatment. The yields from each row were taken separately, then calculated on a hectare basis. The average yield per hectare, the probable error of the mean, and the probable error of the difference were computed (Table 1).

TABLE 1.—*Effect of topping on the yield and color of leaves of the Turkish cigarette tobacco variety Samsoun Bafra*

TREATMENT 1. UNTOPPED OR CONTROL

Row No.	Computed yield per hectare	D	D^2
	Quintals		
A-1	10.00	—2.35	5.5225
A-2	13.57	+1.22	1.5084
A-3	15.00	+2.65	7.0225
A-4	11.78	—0.57	0.3249
A-5	11.42	—0.93	0.8649
Average	12.35	....	$\lesseqgtr d^2$ 15.2432

M = 12.35 ± 0.5888

TREATMENT 2. THE BUD WAS PINCHED OFF BEFORE THE FLOWER HEAD APPEARED

B-1	13.93	+1.42	2.0164
B-2	12.14	—0.37	0.1369
B-3	11.80	—0.71	0.5041
B-4	13.61	+1.10	1.2100
B-5	11.07	—1.44	2.0736
Average	12.51	....	$\lesseqgtr d^2$ 5.9410

M = 12.51 ± 0.3675

B — 12.51 ± 0.3675
A — 12.35 ± 0.5888

0.16 ± 0.6940

TREATMENT 3. THE FLOWER BUD WAS CUT OFF AS SOON AS IT APPEARED

C-1	12.49	—0.54	0.2916
C-2	14.79	+1.76	3.0976
C-3	12.85	—0.18	0.0324
C-4	13.21	+0.18	0.0324
C-5	11.82	—1.21	1.4641
Average	13.03	....	$\lesseqgtr d^2$ 4.9181

M = 13.03 ± 0.3344

C — 13.03 ± 0.3344
A — 12.35 ± 0.5888

0.68 ± 0.6771

TABLE 1.—*Effect of topping on the yield and color of leaves of the Turkish cigarette tobacco variety Samsoun Bafra*—Continued

TREATMENT 4. THE FLOWER HEAD CUT OFF AS SOON AS THE FLOWER OPENED

Row No.	Computed yield per hectare	D	D²
	Quintals		
D-1	12.51	—1.01	1.0201
D-2	14.28	+0.76	0.5776
D-3	13.57	+0.05	0.0025
D-4	12.19	—1.33	1.7684
D-5	15.06	+1.54	2.3716
Average	13.52	....	≤ d² 5.7407

M = 13.52 ± 0.3613

D — 13.52 ± 0.3613
A — 12.35 ± 0.5885

1.17 0.6908

TREATMENT 5. THE FLOWER HEAD CUT OFF AS SOON AS THE CAPSULES WERE FORMED

E-1	10.71	—2.53	6.4009
E-2	13.93	+0.69	0.4761
E-3	13.21	—0.03	0.0009
E-4	15.35	+2.11	4.4521
E-5	13.00	—0.24	0.0576
Average	13.24	....	≤ d² 11.3876

M = 13 24 ± 0.5089

E — 13.24 ± 0.5089
A — 12.35 ± 0.5885

0.89 ± 0.7782

SUMMARY OF TABLE 1

Treatment No.	Mean	Difference against control	Remarks
1 [a]	12.35 ±0.5888	....	No appreciable difference in the color of leaves as noted.
2	12.51 ±0.3675	0.16 ±0.6940	
3	13.03 ±0.3344	0.68 ±0.6771	
4	13.52 ±0.3613	1.17 ±0.6908	
5	13.24 ±0.5089	0.89 ±0.7782	

[a] Control.

Harvesting.—Several methods of harvesting the leaves were tried to determine which method would be the most practical to use. (*a*) Leaves in different stages of maturity were harvested when dark green, when light green, and when ranging from light yellow to bright yellow. (*b*) The leaves were allowed to dry in the field. (*c*) The entire crop of leaves was harvested at one time by cutting off the stalk of the plant at the base before the flowers appeared, when the flowers appeared, and when the capsules were formed. Notes on the color of the leaves were taken after curing.

Curing.—Some curing tests were also performed. The curing methods tried were (*a*) under a nipa shed, (*b*) under a gal-

vanized-iron roof, (*c*) partly under a nipa shed and partly in the sun, and (*d*) completely in the sun. Each method was tested three times. The colors of the leaves cured under the different methods were compared.

Studies on some characters of the variety.—In order to have definite information about this variety the following characters were studied: Height of plant, number of leaves per plant, length and width of standard leaves, percentage of dry weight of leaves on the basis of green weight, form and shape of leaves, texture of leaves, and period of flowering. The first four characters named were also studied in Maligaya, Nueva Ecija. One hundred plants were used as the basis of study. In each case the mean, the standard deviation, and the coefficient of variation were computed (Table 2).

TABLE 2.—*Comparison of Samsoun Bafra variety grown at Alabang and at Maligaya*

COMPARISON OF HEIGHT OF PLANTS OF THE SAMSOUN BAFRA VARIETY GROWN AT ALABANG AND AT MALIGAYA

Locality	Range of variation	Total population	Mean	Standard deviation	Coefficient of variation
	cm.				
Alabang	75–145	100	108.9±1.15	17.08±0.81	15.68±0.39
Maligaya	85–145	100	103.3±0.88	13.09±0.62	12.67±0.30

COMPARISON OF NUMBER OF STANDARD LEAVES OF THE SAMSOUN BAFRA VARIETY GROWN AT ALABANG AND AT MALIGAYA

	cm.				
Alabang	16–36	100	26.6±0.32	4.87±0.23	18.31±0.46
Maligaya	16–36	100	24.8±0.41	6.13±0.29	24.73±0.62

COMPARISON OF LENGTH OF STANDARD LEAVES OF THE SAMSOUN BAFRA VARIETY GROWN AT ALABANG AND AT MALIGAYA

	cm.				
Alabang	16–37	100	26.08±0.35	5.26±0.25	20.19±0.89
Maligaya	16–40	100	25.24±0.26	4.00±0.19	15.85±0.39

COMPARISON OF WIDTH OF STANDARD LEAVES OF THE SAMSOUN BAFRA VARIETY GROWN AT ALABANG AND AT MALIGAYA

	cm.				
Alabang	8–22	100	14.84±0.21	3.15±0.15	21.22±0.55
Maligaya	10–20	100	14.02±0.13	2.21±0.09	16.24±0.40

In the study of the relative weights of cured and green leaves ten determinations were made. The mean and the probable error of the mean were computed (Table 3).

TABLE 3.—*Green and dry weights and percentages of dry weight of leaves*

Determination	Green weight	Dry weight	Per cent dry weight	D	D²
	g.	*g.*			
1	228	40	17.54	—0.47	0.2209
2	217	39	17.97	—0.04	0.0016
3	197	34	17.25	—0.76	0.5776
4	202	34	17.32	—0.69	0.4761
5	216	38	17.59	—0.42	0.1764
6	170	32	18.82	+0.81	0.6521
7	209	39	18.66	+0.65	0.4225
8	175	30	17.14	—0.87	0.7569
9	193	36	18.65	+0.64	0.4096
10	219	42	19.17	+1.16	1.3456
Average			18.01		≶ d² 5.0393

$M = 18.01 \pm 0.0377$

TRIAL CULTURE AT GAGALAÑGIN, MANILA

The seedlings planted in this place came from Alabang. They were planted at practically the same time as in Alabang. The field has been used as a dumping place for all kinds of refuse of late years, so that the soil is friable and comparatively rich in organic matter. The mechanical composition is more or less sandy loam. The lot is owned by the Samson brothers, owners of La Conchita Cigar Factory.

TRIAL CULTURE AT SUCAT, RIZAL

The field is located along the shore of Lake Bay (Laguna de Bay). Because the field was under water until the month of December, 1932, it was not planted until the middle of January, 1933. The seedlings used for planting were raised in that place. The seed was sown during the first week of December, 1932.

The soil is light and porous. It is a silty to sandy loam in physical character, and moist even during the driest part of the year, because the water table is only a few inches below the surface of the ground. This land belongs to Mr. Posadas, collector of Internal Revenue.

DISCUSSION AND RESULTS

Observations on seedlings.—It was observed that the seedlings of Turkish tobacco were more delicate than the seedlings of the other varieties of tobacco. About 50 per cent of the seedlings in Alabang died when they were transplanted in the field. Because of the delicate nature of the stems and leaves, the seedlings succumbed easily to the heat of the sun. For this reason, unless the transplanting is done during cloudy days, it is necessary that the seedlings be covered for the first three or four days to

protect them from the sun. The seedlings are also susceptible to the stem-borer. This is especially true of the older seedlings in the seed beds. The presence of these insects could easily be detected because of the characteristic swelling of the stem of the infested plants. It has been observed that once the plants are attacked by this pest they remain stunted. So it is best to discard all the infested seedlings as soon as they are noticed.

The relation of organic matter and moisture in the soil to the quality of the leaves.—The present investigations revealed some interesting facts about the relation of moisture and organic matter in the soil to the vegetative growth of the plants and quality of the leaves. For instance, in Alabang, where the soil used was heavy clay but well drained, the leaves in the field were generally light in color, and when the same leaves were cured they turned out golden yellow, aromatic, and sweetish in taste.

In Sucat, where the soil was much lighter but moist throughout the year, the plants produced plenty of suckers, and the leaves were coarse and dark green in the field. When the same leaves were cured they either turned greenish or dark brown and were very brittle.

On the other hand, in Gagalañgin, where the soil was also friable and relatively rich in organic matter, the plants developed were taller, with larger leaves, than those grown in either Alabang or Sucat. The leaves were thinner, however. The cured leaves were light brown or greenish but were of good burning quality.

The conditions mentioned in the foregoing two paragraphs refer to the earlier harvests. During the latter part of the season, however, because of drought resulting in the lowering of the water table in both places, the leaves improved in both color and aroma.

Effect of topping on the yield and color of leaves.—Table 1 shows that the topped plants have larger yields than the controls. The differences, however, are insignificant. For instance, in the case of treatment 2, the mean difference is even less than the probable error of the difference. In treatments 3 and 5 the mean differences are almost as great as the probable error of the difference. In treatment 4, in which the mean difference is supposed to be the greatest, it is also insignificant, since it is only about one and one-half times the probable error of the difference.

With regard to the effect of topping on the color of the leaves, as far as the variety under consideration is concerned, no differences in color of the leaves were observed between the check and the treated leaves and even among leaves under the different treatments.

Effect of harvesting and curing on the color of leaves.—In the harvesting experiments the only method that gave really satisfactory results was method 2, whereby the leaves were harvested when they had turned light green. The leaves became bright yellow after curing.

The different methods of curing studied had practically the same effect on the color of the leaves. They differed only in the length of time necessary to cure the leaves. The various methods with the corresponding average number of days it took to cure the leaves were as follows: complete sun curing, 12 days; under a nipa shed then in the sun, 13.3 days; under a galvanized iron roof, 14.6 days; under a nipa shed, 15.6 days.

Height of plants.—Referring to Table 2 it will be seen that the height of plants in Alabang was from 75 to 145 centimeters, while in Maligaya it was from 85 to 145 centimeters. The mean, standard deviation, and coefficient of variation were generally higher in Alabang.

Number of leaves.—In Table 2 it will be seen that the number of leaves of the plants in both places ranged from 16 to 36. The mean was higher for Alabang but the standard deviation and coefficient of variation were lower.

Length of leaves.—The length of leaves in Alabang ranged from 14 to 34 centimeters. In Maligaya, 16 to 40 centimeters. The mean, standard deviation, and coefficient of variation were a little higher in Alabang (Table 2).

Width of leaves.—The width of the standard leaves in Alabang varied from 8 to 22 centimeters. In Maligaya, 10 to 20 centimeters. The mean standard deviation and coefficient of variation were also higher in Alabang (Table 2).

Percentage of dry weight of leaves.—Referring to Table 3 it will be seen that the percentage of dry weight of the leaves ranged from 17.14 to 19.17 per cent. The average of the ten determinations is 18.01 ± 0.0377.

Form and shape of leaves.—In form and shape the leaves are very similar to our native Romero, being heart-shaped and characteristically petiolate.

Texture of leaves.—The laminas are smooth and silky. The midribs and veins are very fine.

Period of flowering.—The variety begins to flower in 100 to 115 days from the time of sowing the seed.

SUMMARY AND CONCLUSIONS

1. The Turkish tobacco type is in a class by itself, both from the standpoint of development of the plants in the field and the quality of the cured leaf products.

2. The average size of the middle standard leaves compares favorably with the maximum size of leaves produced in California.

3. Turkish tobacco thrives in a wide range of soils, provided that these are well drained. Excess moisture in the soil is detrimental to the quality of the leaves. And soil that is rich in organic matter has a tendency to increase the size of the leaves, causing them to lose their peculiar aroma, while apparently poorer soils insure the peculiar desirable qualities of this type of tobacco.

4. From the standpoint of golden yellow color and sweetish aroma the sun-cured leaves produced at Alabang were the best.

5. The variety under study seems to be variable with respect to such characters as height of plants, number of leaves per plant, and length and width of the middle standard leaves. The measurements were higher than those reported by Paguirigan.(2)

6. High topping did not produce any significant effect on the yield and color of the leaves.

7. The average yield per hectare of this variety in Alabang, Rizal, is about 12 quintals. It is higher than the yields obtained at the Ilagan Tobacco Station during the 1928–1929, and 1931–1932 seasons.(3)

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ILLUSTRATION

PLATE I

FIG. 1. Typical plant of the Samsoun Bafra (Turkish) tobacco variety grown in silty loam soil. Note the broadness of the leaves.

2. Typical plant of the Samsoun Bafra (Turkish) tobacco variety grown in clay loam soil.

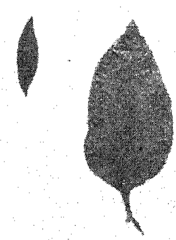
3. Plot of Samsoun Bafra (Turkish) tobacco variety grown in a loam soil rich in organic matter, Gagalañgin, Manila.

4. Typical top and middle standard leaves of the Samsoun Bafra (Turkish) tobacco variety.

1

2

3



4

PLATE I

A SURVEY OF THE VEGETABLE INDUSTRY IN BAGUIO AND IN TRINIDAD VALLEY, MOUNTAIN PROVINCE, LUZON

By PEDRO A. RODRIGO

Of the Bureau of Plant Industry, Manila

TWO PLATES

The vegetable gardens in Baguio and in Trinidad Valley, Mountain Province, are considered the most extensive as well as the most intensive truck-farming project in the Philippines. Practically all of Guisad and Lucban Valleys and all the sections of Trinidad Valley suitable for vegetable growing are devoted to the industry. A conservative estimate places the area set out in vegetables in 1932 at over 200 hectares, and they grow virtually all the year round.

This investigation was undertaken to find out what practices make the industry successful, and to gather information that would be useful in the promotion of vegetable growing in the lowlands. It was also thought that it might show some possible ways to maintain or improve the industry.

This work was undertaken by the writer during his stay at the Baguio Semi-temperate Fruit Station, Baguio, Mountain Province, from October, 1930, to August, 1932.

HISTORY OF THE INDUSTRY

People who have lived in Trinidad Valley and Baguio for the last sixty-five years claim that some sort of vegetable growing was done there by the natives and the few Spanish missioners before American occupation. The Spaniards introduced the Irish potato, and although the natives were naturally lazy about cultivating it, through some forced means at first, they came to like it and finally grew it quite extensively.

Camotes and gabe were the two staple crops, and together with other vegetables, they were grown in the higher portions of Trinidad Valley. The valley about fifty years ago was almost all under water during the greater portion of the year,

due to the lack of adequate drainage canals. Towards the end of the Spanish régime cabbages, radishes, and lettuce were grown in kitchen gardens of Spanish residences. Cabbages were propagated almost wholly by slips or branches.

The rapid development of the vegetable industry began during the early part of American occupation. As early as 1903 an experiment station (Trinidad Garden) was established in Trinidad Valley, at the present site of the Trinidad Agricultural School, by the Government, under the old Bureau of Agriculture. The station had for its primary purposes the "testing of temperate and tropical vegetables, . . . and the experimental marketing of the ordinary varieties which can be economically produced in wholesale quantities." While the station did not last long, as it was ceded to the Bureau of Education, its work served as an eye-opener to the great possibilities of Baguio and Trinidad Valley in the growing of high-priced and insistently demanded temperate and semi-temperate vegetables. As one superintendent of the station reported, ". . . this work (vegetable growing) has reached the stage where it is an unquestionable success, and as a consequence many of the Igorots and Ilocanos are starting vegetable gardens of their own."

The establishment of the Trinidad Agricultural School further assisted the development of the industry. The children of the natives were afforded the rare opportunity of learning the art and science of vegetable growing in the school. At the present time, many of the most successful gardeners among the natives are alumni of the school. The construction of a canal by the school to drain the valley also greatly increased the area that could be devoted to vegetable growing.

Japanese as well as Chinese gardeners, particularly the former, have contributed a great deal towards the development of the vegetable industry. As early as 1898, a Japanese settled in Trinidad Valley and did some home gardening. In 1907 there were as many as twenty-five Japanese gardeners in the whole valley, and in 1930 there were fifty of them actually engaged in vegetable gardening besides a goodly number that were working as laborers under Japanese gardeners.

The Japanese gardeners introduced Japanese methods and practices. It was a Japanese who first used a glasshouse for the raising of seedlings for planting purposes. This was in 1907.

It was also either a Japanese or Chinese gardener who introduced the use of the "raised bed" method, which is now universally followed in the valley, including the Trinidad Agricultural School.

In the raised bed, the land is so worked that the soil in the plot is very much higher than the paths. In the valley the beds are about 1 meter wide, accommodating two rows and of any convenient length. The paths are like drainage canals between the plots.

This method, while more expensive than the "flat method," because it involves a great deal of manual labor, the use of animal-drawn implements not being feasible, has several advantage over the latter. Among the most important are that it insures thorough preparation of the soil, leaving a deep medium of friable yet firm and mellow soil; it insures thorough drainage even during the rainy season; and it provides paths without sacrificing space. Thus the soil intended for plants is never stepped on and compacted.

The Japanese gardeners are also credited with the introduction of some of the vegetable crops that are widely grown in the valley. The most important is the Japanese-Irish potato.

The Chinese contributed no less towards the development of the vegetable industry in Trinidad Valley. In 1907, perhaps, encouraged by the success of the old Bureau of Agriculture in raising semi-temperate vegetables, a number of Chinese gardeners went there to try their luck. By 1916, there were about forty of them, and their number has been about the same to the present time. Like the Japanese, because of their diligence and great preseverance in working against great odds, and because of their experience in their own country, they have contributed much to bringing the industry to its present status. The introduction of the Shanghai cabbage, one of the kinds best adapted to local conditions, and undoubtedly the best variety for rainy season planting, is attributed to the Chinese gardeners. And so with the Chinese green onion; two varieties of the common bean, *Phaseolus vulgaris;* and the Chinese cabbage, *Brassica pekinensis,* a very delicious type of pechay.

The thoroughness with which the soil is prepared for planting and the more or less free use of manures, especially crop residues, may be rightly attributed to either the Chinese or the Japanese.

THE SOIL AND CLIMATE OF BAGUIO AND TRINIDAD VALLEY

Soil.—The common soil in Baguio and in Trinidad Valley is red clay. This soil is very sticky when wet, but it crumbles easily upon exposure to air and sun as it lacks soil colloids. However, it is not the kind that is found in the valley which are devoted to the growing of vegetables. That soil is generally made up of decomposed shales and the sedimentary lime rock that is abundant in many of the mountains surrounding the valleys. In many places it is liberally intermixed with silt containing some sand. Originally it must have been poor, but it has been brought to its present state of fertility through the lavish use of plant residues, ashes, stable manures, and commercial fertilizers.

Climate.—The portions of Baguio and Trinidad that are suitable for the growing of vegetables have an elevation of about 1,400 meters above sea level. The climate is agreeable, especially during the dry months, when it is cool and decidedly refreshing.

Baguio and the surrounding country enjoy the first type of climate, having a wet and a dry season that are quite distinct. The rainy season extends from May to October, during which time there is an excessively heavy rainfall, especially during the months of July and August. A study of Table 1 will give some idea as to the climate of Baguio and its immediate vicinity.

TABLE 1.—*Showing the average monthly rainfall, number of rainy days per month, temperature, and relative humidity in Baguio for a period of ten years, 1922–1931* [a]

Climatic factor	Month						
	Jan.	Feb.	Mar.	Apr.	May	June	July
Amount of rainfall........mm...	10.3	15.4	32.4	105.9	388.8	550.9	935.4
Rainy days....................	3.7	2.4	5.1	9.4	23.2	24.8	28.3
Temperature ....°C..	16.9	17.2	18.1	18.9	18.9	18.5	18.0
Relative humidity.............	77.8	77.3	79.0	81.5	87.9	90.7	92.1

Climatic factor	Month					Total
	Aug.	Sept.	Oct.	Nov.	Dec.	
Amount of rainfall...............mm...	1,157.1	608.9	326.3	107.0	30.1	4,268.5
Rainy days........................	27.7	25.8	19.2	10.2	5.9	185.7
Temperature........................°C..	17.6	18.0	18.0	17.9	17.2	....
Relative humidity.....................	93.7	92.0	88.4	83.8	79.1	....

[a] Data compiled from the Weather Bureau records.

As seen in Table 1, while the relative humidity is high, the temperature is comparatively low, approaching that of temperate countries, thus making the region suitable for the growing of semi-temperate and some temperate crops.

PRESENT STATUS OF THE INDUSTRY

Area under cultivation.—In 1903, only an insignificant portion of the entire Guisad, Lucban, and Trinidad Valleys were planted to gabe and sweet potatoes, but by 1930 the whole of the Guisad and Lucban Valleys and about half of Trinidad Valley had been turned into intensive truck gardens. A conservative estimate for that year placed the area devoted to vegetables at over 200 hectares.

Classes of gardeners.—For the purpose of this paper, the gardeners may be classified as owners and tenants. Owner-gardeners are natives who have acquired the art of gardening through schooling or through their association with Chinese or Japanese gardeners. The tenant-gardeners seem to be more numerous and most of them are Chinese and Japanese. They are more progressive than the first group of gardeners. The tenant-gardeners hire the land on which they work for a number of years, paying from 150 to 300 pesos a hectare a year. A few shrewd Japanese and Chinese have married native women, thus becoming entitled to work the land of their wives.

The owner-gardener cultivates about one-fourth to one-half a hectare. In general he does not employ any labor; he works his garden with the aid of his family. On the other hand, the tenant-gardener handles from one to three hectares. He employs laborers ranging in number from three per hectare during the rainy season to eight per hectare during the busiest season of the year.

Principal crops grown and their relative importance.—When one goes to the Baguio market, he will be impressed with the array of different kinds of vegetables. It will be noted, however, that only a few crops are grown on a large scale. The principal reasons are the demand for these particular crops, and the income that can be realized from their culture.

The most popular and widely grown crop in the whole region is undoubtedly the cabbage. It is safe to state that about three-fourths of the whole area devoted to vegetables is planted to

cabbages. Next in importance are pechay (mostly the type that produces a head), beans, strawberries, green onions, peas, sweet potatoes, and Irish potatoes. Lettuce, celery, carrots, beets, tomatoes, cauliflowers, peppers, eggplants, cucumbers, kohlrabi, spinach, chayotes, rhubarb, leeks, endive, etc., are grown in limited areas to supply the local demands and sometimes for shipment to Manila.

TABLE 2.—*The more-important vegetables and the more commonly grown varieties under each*

Cabbage:
- Shanghai. Best for rainy season culture.
- Flat Dutch. } Best for dry season culture.
- Succession. }
- Allhead Early.

Pechay:
- Wong Bok. Produces head.
- Chinese.

Beans:
- Chinese Black.
- Chinese Wax.
- Kentucky Wonder (black).
- Canadian Wonder.

Peas:
- Alderman.
- Chinese.

Irish potato:
- Japanese White.
- Japenese Red.
- Spanish. Neutralized.

Green onions:
- Chinese.
- Japanese.

Sweet potato:
- Native. Several varieties.
- American. Unidentified.
- Samar Big Yellow.

Peppers:
- Rubi King.
- Chinese Giant.

Tomato:
- Ponderosa.
- Marglobe.

Beets:
- Improved Blood.

METHODS OF CULTURE IN VOGUE

The method of culture in Trinidad Valley and in Baguio is distinctly Oriental. This is as is to be expected, because the leading gardeners are Japenese and Chinese. Even the Trinidad Agricultural School, the principal of which is an American, employs the "raised bed" system (Plate I, fig. 1). "We have to adopt the system (raised bed) if we want to get the maximum yield," the principal once said.

Preparation of the soil.—The preparation of the soil for planting vegetables in the whole district is done by manual labor except in the Trinidad Agricultural School and the Baguio Semi-temperate Station, where animal labor is employed to a certain extent. Raised beds are made no matter what crops are raised. The soil, however, is easy to prepare, except for the newly reclaimed areas bordering the lake. It crumbles easily even if it is rather wet due principally to the combined effects (*a*) of continuous cropping, which prevents the excessive growth of weeds and at the same time renders the soil soft, and (*b*) of the continuous heavy applications of stable manures, ashes, and crop residues in the form of humus. The Igorots from different parts of the Mountain Province supply most of the labor. The daily wage ranges from 60 to 80 centaves, with free food, but the working hours are from daybreak until quite dark in the evening.

For the preparation of the soil, the Japanese hoe (the blade is similar to the tines of a spading fork, but mounted like that of a grub hoe) is the one that is used almost exclusively. This hoe is used for digging the soil, pulverizing it, and making holes in which to set out the plants so that in itself are combined the plow, the harrow, and the trowel of the vegetable gardener in Baguio and in Trinidad Valley. Spading forks, garden hoes, and rakes are seldom if ever used except in the Baguio Semi-temperate Station and in the local agricultural school.

In the preparation of the soil, there is one unique practice employed that farmers in the lowlands should think about. All crop-remains, like leaves, stems or vines, stubs, etc., including all weeds, are collected and never mixed or buried in the soil. If they were then they would be bound to have some bad effect on the following crop inasmuch as no time would be given them

to decay, even only partially, before planting. Such materials are not burned, however, as in the lowlands, but are gathered and dumped into a compost pit (Plate I, fig. 2) where they decay for future use.

Sources of seed.—Except as to native vegetables, and to some extent beans, peas, and perhaps lettuce, pechay, radishes, and other minor vegetables, the vegetable industry in Baguio and the Trinidad Valley is dependent upon foreign or imported seeds. Cabbage, potato, beet, celery, endive, carrot, etc., seeds are imported from the United States, Japan, China, and perhaps from other countries. Many of the vegetables grown in the Trinidad Valley do not produce seeds, or if they do produce them, such seeds may not be as good as those from foreign countries. This feature of the industry is not satisfactory, at its best. The presence of serious pests and diseases in the valley are attributed to the importation of seeds.

Raising of seedlings.—The use of good seedlings for planting purposes is one of the principal factors in the successful growing of vegetables. Because of the excessive rainfall from May to October, and because of the rather low temperature from November to February, the use of a glasshouse (Plate II, fig. 2) was found indispensable. The soil in the glasshouse is raised about 30 centimeters above the surrounding ground. The bottom layer is composed of gravel and sand to provide good drainage, while the top soil is composed of sandy loam, mixed with plenty of organic matter and a little ash. The top soil is changed at least once a year. Gardeners who cannot afford to put up a glasshouse build a shed for the raising of seedlings or grow their seedlings in boxes. Seedlings produced by the last two methods are very much inferior to those raised in glasshouses.

Vegetable crops like cabbage, pechay, onion, pepper, eggplant, tomato, lettuce, celery, kohlrabi, cauliflower, etc., are first grown in seed beds and then are transplanted in the garden when they are big enough. Many of the gardeners broadcast their seeds on the surface of a well-prepared bed, be it in a glasshouse or in the open, and cover them with fine soil and a little ash. The more progressive ones sow their seeds thick in a certain section of the glasshouse and then prick the seedlings later on. While this method is certainly more expensive, the uniform stand of the seedlings, to say nothing of their stoutness, and the effect of these in the subsequent stand of the crop in the field warrant the practice of the pricking method.

MANURES AND COMMERCIAL FERTILIZERS

One who is not informed concerning the extent to which stable manures and commercial fertilizers are used in connection with vegetable-growing in the valley will wonder how it is possible to raise three or more crops a year on the same piece of land year after year, knowing, as already stated in the first part of of this article, that the rainfall is indeed excessive and raised beds are employed—all conducive to the facile washing off and leaching out of plant food materials. Although the gardeners probably are not thinking of their duty to posterity to maintain the fertility of the soil for generations yet unborn, the fact is that they apply great quantities of farm manures and commercial fertilizers to the soil. They do realize that they cannot be producing good crops all the time from the same piece of ground without returning what they get from the soil in the form of fertilizers.

In the valley, commercial fertilizers, stable manures, ashes, and all sorts of crop residues are applied to the soil frequently and in great quantities. The liberal use of farm manures, commercial fertilizers, insecticides, and fungicides has caused a comparatively high production cost,[1] but is one of the principal factors responsible for the success of the industry.

Stable manure, ash and compost.—The soil in the vegetable gardens in the valley is friable and black, and at the same time firm and mellow. This condition is principally due, not to the nature of the soil, for it is generally red and sticky, but to the heavy application of organic matter in various forms. No crop is grown without the application of some compost and commercial fertilizers. The soil, therefore, may be manured and fertilized three or more times a year, depending upon the number of crops grown.

The common sources of organic matter are stable manures, compost from crop residues and weeds, and the charcoal[2] of pine leaves and grass. Soybean cake and fish meal, which are used in great quantities, are also good sources of organic matter.

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[1] It costs from 7 to 8 centavos to raise one cabbage plant from seed to maturity.

[2] This charcoal (locally known as ash) is made by burning pine leaves and partially dried grass. After it is charred, it is sprinkled with water so as to prevent the total conversion of the stuff into ash. Analysis made by the Bureau of Science gives the following composition: P_2O_5, 0.68 per cent; K_2O, 0.79 per cent. One can of this ash weighs about 6.36 kilos and sells for from 8 to 12 centavos.

These are partially rotted first by thoroughly moistening them for a couple of days before applying them. The garbage collected in the City of Baguio is burned in an incinerator, and the ash is sold to the gardeners.

Commercial fertilizers.—Commercial fertilizers like stable manures and composts are applied in great quantities. The gardeners realize that without the use of some commercial fertilizers, vegetable crops of fine quality cannot be produced.

The commonest commercial fertilizers used in the valley are ammonium sulphate, fish meal, soybean cake, superphosphate, guano, and sulphate of potash.

Method of mixing and applying fertilizers.—The way fertilizers are mixed is based upon practical experience. The gardeners invariably get a good stand of crops because of the fact that they mix different kinds of fertilizers, that naturally supply the three important manurial elements. The writer saw a number of gardeners who mixed about six parts of stable manure or compost, three parts of soybean cake and fish meal, and one part of potash and phosphorus fertilizers. This combination is claimed to be good for any crop. Ash is generally applied separately and mostly to root and tuber crops and to beans and peas.

When the young plants have started growth they are treated with ammonium sulphate, mostly in solution.[3] Here comes the difference between the treatment of leaf crops and root or fruit crops. The leaf crops receive several doses of the treatment, while other crops generally get one or two just to give the plants a good start.

One of the unique features in the method of applying fertilizers in the whole region is the concentration of the fertilizer where it is needed. Instead of being spread all over the field, it is put in holes or furrows previously made for the reception of the plant or seed. The reason is obvious. The fertilizer is placed within easy reach of the roots, thus causing early and vigorous growth. Any treatment that tends to bring this about is desirable in vegetable growing.

[3] One canful (milk can, pint size) of ammonium sulphate is dissolved in one petroleum canful (5 gallons) of water, and this is utilized to water about 100 to 200 plants.

CULTIVATION AND IRRIGATION

Because of the thoroughness of the soil preparation before planting, any cultivation beyond the destruction of weeds is seldom practiced. Irrigation, however, especially during the dry months, is a very important operation. Practically all the crops raised, with the exception of solanaceous crops like the potato, tomato, eggplant, pepper, etc., beans and peas, require much watering for their development. So every garden is provided with an irrigation canal from which water is taken in watering cans. The leaf crops, like cabbage, pechay, lettuce, celery, cauliflower, etc., need to be watered every day during the dry months, until near maturity, when watering is regulated so as to hasten the process.

HARVESTING

All crops are harvested as soon as matured. The harvesting is seldom delayed even if the crop is in no danger of being destroyed. The reason is to have the ground cleared so it can be prepared for another crop, thus keeping the field always occupied with some crops, provided weather conditions permit.

The manner of harvesting depends upon the kind of crop and as to whether it is intended for the local market or for distant shipment. Vegetables for the local market are generally harvested late in the afternoon previous to the market day, or they may be harvested very early in the morning. The object in thus cutting the vegetables as late as possible is to deliver them very fresh. Fresh vegetables of fine quality always sell easier and generally at better prices. Vegetables for long distance shipment are generally harvested in the morning of the day for shipment. These vegetables are put in bamboo crates (Plate 2, fig. 2) when any adhering water has dried up or when the stuff has wilted a little so as to minimize any danger of their rotting while in transit. These are shipped to Manila and other places by rail and by some private transportation companies.

MARKETING

The principal markets of the Baguio and Trinidad gardeners are the cities of Baguio and Manila. Vegetables are also shipped to some big towns like Dagupan, Tarlac, Angeles, San Fer-

nando, etc., but the amount sent to these places is insignificant compared with what is sold in Manila. Tables 3 and 4 give some idea as to the output of vegetables from Baguio and Trinidad Valley, and the months of the year when shipment is heaviest. Data on shipments through private companies were not available but these are believed to be greater than those shipped by the railroad because of lower freight charges.

TABLE 3.—*Monthly shipments of vegetables from Baguio to different provinces per the Manila Railroad Company in 1931*

Province	Month						
	Jan.	Feb.	March	April	May	June	July
	Kilos	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*
Albay	265	297	42	27	20	....	15
Batangas	....	16	18	30	135	9	14
Bulacan	145	45	149	1,173	325	18	75
Camarines Sur	....	....	....	....	130	....	....
Capiz	....	23	....	....	....	....	....
Cavite	375	621	433	10	73	....	....
Ilocos Sur	....	83	....	9	33	....	30
Iloilo	....	....	....	....	53	....	....
Laguna	392	147	344	549	849	558	316
La Union	365	135	572	442	411	171	336
Manila	70,267	40,410	81,226	63,599	74,607	35,531	31,242
Nueva Ecija	25	36	164	216	186	40	15
Occidental Negros	21	....	....	....	....	....	....
Pampanga	3,545	2,583	4,408	5,310	6,488	4,200	3,549
Pangasinan	771	322	174	378	415	392	379
Rizal	22	26	33	414	221	85	209
Tarlac	3,108	1,929	1,813	2,283	2,604	2,549	2,703
Tayabas	55	15	57	197	597	87	58
Total[a]	9,089	6,278	8,207	11,038	12,540	8,109	7,699

Province	Month					Total
	Aug.	Sept.	Oct.	Nov.	Dec.	
	Kilos	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*
Albay	....	....	44	26	50	786
Batangas	....	....	....	....	26	248
Bulacan	13	....	25	30	611	2,609
Camarines Sur	....	....	....	....	53	183
Capiz	....	....	....	....	....	23
Cavite	....	....	....	....	....	1,512
Ilocos Sur	66	18	52	8	44	343
Iloilo	....	....	....	....	....	53
Laguna	62	110	211	231	373	4,142
La Union	40	57	225	253	437	3,444
Manila	16,221	9,341	17,767	28,290	59,742	528,243
Nueva Ecija	....	....	18	9	52	761
Occidental Negros	....	....	....	....	8	21
Pampanga	1,096	509	406	1,488	4,200	37,862
Pangasinan	232	69	343	489	615	4,579
Rizal	14	....	21	45	139	1,229
Tarlac	646	158	451	1,979	1,864	22,087
Tayabas	....	....	....	29	71	1,166
Total[a]	2,169	921	1,796	4,587	8,615	609,291

[a] That to Manila not included in the total.

TABLE 4.—*Comparative monthly and total shipments of vegetables from Baguio to Manila, and to all provinces combined in 1931 and part of 1932.*[a]

Month	Manila			All provinces (railroad)	Total
	Through Manila Railroad	Trinidad Garage	Total		
	1931				
	Kilos	*Kilos*	*Kilos*	*Kilos*	*Kilos*
January	70,267	(b)	70,267	9,089	79,356
February	40,410	....	40,410	6,278	46,688
March	81,226	....	81,226	8,207	89,433
April	63,599	....	63,599	11,038	74,637
May	74,607	....	74,607	12,540	87,147
June	35,531	....	35,531	8,109	43,640
July	31,242	....	31,242	7,699	38,941
August	16,221	....	16,221	2,169	18,390
September	9,341	....	9,341	921	10,262
October	17,767	....	17,767	1,796	19,563
November	28,290	....	28,290	4,587	32,877
December	59,742	....	59,742	8,615	68,357
Total	528,243	....	528,243	81,048	609,291
	1932				
	Kilos	*Kilos*	*Kilos*	*Kilos*	*Kilos*
January	57,458	73,436	130,894	5,186	136,080
February	68,201	64,908	133,109	6,858	139,967
March	94,619	120,900	215,519	12,491	228,010
April	....	104,982	104,982	....	104,982
May	....	140,538	140,538	....	140,538
June	....	....	....	....	....
July	....	....	....	....	....
August	....	....	....	....	....
September	....	....	....	....	....
October	....	....	....	....	....
November	....	....	....	....	....
December	....	....	....	....	....
Total	220,278	504,764	725,042	24,535	749,577

[a] Complete figures for 1932 not presented due to impossibility of getting data from the Railroad Company.

[b] Not available, but shipments by the Trinidad Garage and other companies are believed to have been much greater than those by the Manila Railroad Company; practically all shipped to Manila.

As an aid to more effective marketing, the gardeners in Baguio and in the valley have certain associations. In these they formulate regulations, which, among other things, promote their industry, particularly the selling and buying ends. In 1932, there were three such associations; namely, the Filipino Gardeners' Association, the Japanese Agricultural Association, and the Chinese Gardeners' Association. While these organizations may have some racial tendencies and rivalries, they have arrived at a certain understanding that so far has proved beneficial to their industry. One of their agreements has reference to the

marketing of cabbages, the most important of all vegetable crops raised in the valley.

Because of the great quantities of cabbage produced throughout the whole vegetable season, it was thought necessary to regulate the selling of the commodity so as to prevent any possible glutting of the market with this one vegetable crop. Thus they decided to have two days in a week when cabbages could be sold in quantity. During these days, a gardener is entitled to sell only 25 kilos of cabbage in the Baguio market, but he is free to ship any amount to Manila and other places. This agreement of the three associations has two important features: (*a*) The amount of cabbages that enters the Baguio market is regulated, thus the local price is maintained at a reasonable level; and (*b*) the frequency of placing fresh cabbages on the market, either in Baguio or elsewhere, is limited to twice a week. This enables retailers and agents to sell their old stocks before any fresh lots come in; hence the gardeners as well as the agents and the retailers are reasonably protected.

For the benefit of vacationists, who may leave Baguio any time, the gardeners are at liberty to sell cabbages any day of the week in their own gardens without incurring any penalty, provided the total amount does not exceed 15 kilos a day. Other vegetables raised in the locality can be sold anytime and without any limitations as to amount.

Each association has its agents in Manila. The associations buy seeds and commercial fertilizers in coöperation thus effecting their purchase more cheaply.

CROP ROTATION

While it is universally recognized that crop rotation is one of the major principles upon which successful farming depends, its systematic practice is not much in vogue in the valley, because of the big demand for a few vegetables, and because of the limited area that a gardener works for a living.

In Trinidad Valley and in Baguio any systematic crop rotation is practically relegated to the background. Cabbages occupy the lion's share in the growing of vegetables. Pechay follows. The common cropping method in vogue is continuous planting of cabbages, season in and season out, for a number of years on the same piece of land, though cabbages and pechay may alternate. But while in the latter case there is an actual change of crops, it is not regarded as a rotation because the crops are

of the same family, and they are both leaf and shallow-rooted crops. It is not a rotation that tends to minimize the appearance of repressive agencies nor one that tends to maintain soil fertility.

The effect of this continuous growing of one kind of crop or crops of the same family in the same piece of ground has already manifested itself in the stand of the crops, and the more progressive gardeners have begun to realize it. I have been shown a piece of land that has been cropped to cabbages alone (three crops in a year) during the last twelve years! In this lot more than 50 per cent of the plants died because of various fungus diseases, mostly black leg in the early dry season crop in 1931.

In the poorer sections of certain fields a sort of crop rotation is being practiced, not because the farmers desired it, but because it is necessary. There, the minor crops are raised, and because of their number, and perhaps, because of their climatic preferences, they are planted in a sort of rotation. The gardeners who have the "eyes to see" realize the advantage of this method of cropping, especially in connection with the prevalence of fungus disease that stay in the soil. Such farmers claim that cabbages and potatoes in rotation prove quite advantageous in the control of certain diseases like the black leg of cabbage.

INSECT PESTS AND DISEASES

Because of the intensiveness of vegetable growing there are a number of insect pests and diseases that if not vigorously combated may sooner or later prove fatal to the industry. It is not, however, the purpose of this paper to enumerate all the pests and diseases found in the valley; only the serious ones are mentioned.

Insect pests.—The most important insect pest and the one most intensively fought against is the cabbage worm. It feeds on many plants, but it does the most damage to cabbages and pechay. Fortunately it is not present in abundance during the rainy season when spraying is not practicable.

The pest is controlled by the frequent use of insecticides. The ones commonly used are a preparation of pyrethrum and lead arsenate. The former is a contact poison that is more generally used throughout the region because of its effectiveness, and safety to man as well as to plants, while lead arsenate is usually used when the plants are still small. As long as it is not

washed off, it means less frequency of spraying. However, the moment the plants begin to form heads or even before that, the other kind is used. The claim commonly made as to lead arsenate is that even when the right concentration is used, there is some slight burning of the forming heads, which naturally affects their development. Some observations made by the writer confirmed this claim. Upon drying, a considerable amount of the lead arsenate in the spray collected on the margin of the young leaves, particularly on the forming heads, and this, aided, by the hot sun caused the burning. Where this occurred, the development of the head was affected and naturally its market value. The trouble with the pyrethrum preparation is that its price is high. Derris, a Philippine product, may prove as effective.

During the dry season, when the pest is at its worst, spraying twice a week has been found to be sufficient. Spraying generally ceases when the heads are well formed.

Other insect pests that may be mentioned are flea beetles, which attack plants of the cabbage family, and red spiders, which attack peas.

Diseases.—The fungus diseases, while more numerous are considered by the planters as less destructive. Yet they are, no doubt, causing considerable damage. Foremost among these are the potato and tomato blights. No potatoes will mature properly, and a good crop of tomatoes cannot be had without the judicious use of Bordeaux mixture spray. Other serious diseases are the black leg and soft rot of cabbage, potato scab, tomato wilt, bean blight, and celery blight.

SOME PROBLEMS OF THE GARDENERS AND THEIR NEEDS

While the gardeners seem to be doing well, they have some problems that they cannot well cope with, and problems that sooner or later may arise as an inevitable result of present practices. These need technical men for their proper solution. Perhaps, it is in the solution of these problems that the Bureau of Plant Industry may be of service to the gardeners.

Some of the more important problems are here presented, not that they may soon be studied, but their mere enumeration may serve as a working guide in the formulation of plans for the future activities of the Experiment Station in Baguio, Mountain Province.

Of the more important problems, the following may be mentioned:

1. *The use of manures and commercial fertilizers and their application.*—The Baguio and Trinidad gardeners may be considered as past masters of the art of gardening. But while they seem to be successful, the questions arise: Are their practices the best and most profitable, and are these not conducive to the development of certain diseases and toxic substances in the soil that may ultimately have ill effects on the crops? In this connection, the writer wishes to bring forth the need for (*a*) a more economical use of fertilizers, (*b*) the most suitable fertilizer or combination of fertilizers for a given crop, (*c*) the amount to be supplied and the frequency of application, and (*d*) the best time to apply such fertilizers. Also, the residual effect of such fertilizers on the crop and in the soil must be determined—whether beneficial or deleterious. In bringing out these points, the writer does not mean to belittle the ability of the gardeners in the use of manures and commercial fertilizers. In fact, one who visits them, particularly the more progressive Japanese gardeners, will invariably find something to learn. But since they are working to make a living in the present, with little or no thought for future years, they are prone to overlook some of the dangers that may ensue as a result of their present practices. Besides, such gardeners cannot afford to test the use of new discoveries that may affect their callings.

2. *Crop rotation.*—In considering the question of crop rotation, three important questions arise; namely, the maintenance of the fertility of the soil, the control of pests and diseases, and the growing of the crop that gives the most net profit.

The present practice, which has been in vogue during the last fifteen to twenty years, is a highly intensive one-crop system. Such a practice must undoubtedly have been the cause of a number of plant diseases and pests that are prevalent in the region. The set of studies in connection with crop rotation should include the possible control of pests and diseases in connection with the growing of the crops that give the most return even considering the expense of maintaining soil fertility. This last factor can properly be met with the use of suitable fertilizers.

3. *Insect pests and diseases.*—The success of vegetable growing in Baguio and in Trinidad Valley is predicated upon the ef-

fective control of pests and diseases. This is especially true of the cabbage and its relatives, Irish potatoes, tomatoes, peas, etc. On the control of the cabbage worm, the black leg and soft rot of cabbage, the potato and tomato blights, potato scab, red spiders, etc., will depend the future of the vegetable industry in this region. These matters need serious consideration. The point may be raised: Is it not possible to completely eradicate the cabbage worm from the region—a valley surrounded by forests and away from outside sources of infection?

4. *The seed and its production.*—In the discussion of this topic, seed is classified into imported seed and home-grown seed. The vegetable industry in Baguio and in Trinidad Valley will always, perhaps, depend partly upon imported seed. The production of cabbage seed and some of its relatives and the storing of potato seed tubers are still problematical. Some isolated attempts in the Mountain Province have produced cabbage seeds, but such seeds were found to be poor. However, it is now definitely known that there are only a few favored places in the world where good quality cabbage seed can be produced. As to Irish potatoes, there is still the possibility of raising seed tubers during June and July in certain sections of the Islands. There is also a strong indication of the possibility of naturalizing an exotic variety in the Mountain Province. The Spanish potato has been grown in the Mountain Province since the Spanish regime. This variety may be used as a basis of breeding work on potatoes. Work on the acclimatization of foreign varieties may be fruitful of good results.

In connection with seed potatoes that the local gardeners will have to import,—the variety or strain among the imported kinds that will be best suited to local climatic and soil conditions must be ascertained. In the present stage of the seed industry in the United States and in some other countries, it is possible to obtain the history of the seeds that are sold. Seeds of known history can be imported, these tried here and the kinds best adapted to certain sets of conditions ascertained. Some arrangement could be made with the institutions or companies that produce the seed found best under local conditions so that they will produce all that is needed every year. The Bureau of Plant Industry, as in the case of Bermuda onions, may undertake the buying and selling of the seeds. In this way, the quality of the seed will always be assured, and if need be, the seeds can be properly disinfected before being sold.

With respect to home-grown seed, the best variety or strain of each crop should be selected, either through acclimatization, variety test, or line selection. Hybridization can be resorted to to evolve new varieties or strains. In this particular field, there are great opportunities for the local plant breeders to produce varieties or strains that will suit the varied conditions in the valley and in the whole country.

SUMMARY AND CONCLUSIONS

1. This study was conducted for about two years. Observations were made throughout the year on the practices among the Japanese, Chinese, and native gardeners in Baguio and in Trinidad. Private gardeners and others who have lived long in the region were interviewed.

2. The vegetable industry in Trinidad Valley and in Baguio was primarily the direct result of the work of the former Baguio Experiment Station established in 1903 in Trinidad Valley by the old Bureau of Agriculture. The Trinidad Agricultural School, which followed the experiment station, as well as the Japanese and Chinese gardeners, had their due share in bringing the industry up to its present level.

3. The region enjoys a more or less semi-temperate climate and is adapted to the growing of temperature and semi-temperate crops. The principal crops are cabbage, pechay or Chinese cabbage, beans, strawberries, green onions, peas, Irish potatoes, sweet potatoes, celery, beets, cauliflower, etc. Cabbage constitutes about three-fourths of the total vegetable crops.

4. The vegetable industry is both extensive and intensive. All of Guisad and Lucban Valleys in Baguio, and the suitable areas for vegetables in Trinidad Valley are devoted to vegetable growing. The total area was estimated to be over 200 hectares in 1932, and practically all of this area was under some crops of vegetable throughout the year.

5. Besides the natives, Japanese and Chinese constitute the rest of the gardeners. The last two are tenants, paying from 150 to 300 pesos per hectare per annum. They are, however, the more progressive, especially the Japanese, and they have larger gardens.

6. Manual labor is the sole source of power in the preparation of the soil for planting. The Japanese hoe is the most important tool in the valley, and it is used for digging and pulverizing the soil, and in making holes for the reception of the seed or

plant. The natives from different parts of the Mountain Province supply most of the labor. The daily wage is from 60 to 80 centavos with food, but the laborer has to work from daybreak until dusk.

7. The raised bed method is employed throughout. This method makes the thorough working of the soil easy, provides excellent drainage even during the rainy season, and leaves paths between the plots. Thus the areas devoted to plants are never stepped on nor compacted.

8. Most of the seeds planted are imported, principally from the United States, Japan, and China. Beans, peas, tomatoes, peppers, and a few species are generally propagated from seeds produced locally.

9. The success of the gardeners in Trinidad Valley and in Baguio is attributed mostly to (*a*) the thorough preparation of the soil; (*b*) the liberal application of stable manures, decayed crops residues, ashes, and commercial fertilizers; (*c*) good control of many of the more important pests and diseases with the use of insecticides and fungicides; (*d*) the liberal use of irrigation water; and (*e*) industry, diligence, and coöperative spirit of the gardeners.

10. Very little rotation, if any, is being done by the gardeners; the practice in vogue is mainly a one-crop system. Gardeners, however, are beginning to realize the bad effects of such a method of cropping in spite of the liberal use of commercial fertilizers and organic matter.

11. Some of the most important pests and disease are cabbage worms, cut worms, red spiders, potato and tomato blights, potato scab, black leg and brown rot of cabbage, and blight of celery.

12. The gardeners have formed coöperative associations. The selling of cabbage is regulated so that there are only two market days for cabbages a week. A gardener may sell 25 kilos of cabbage in the Baguio market and may ship any amount to Manila and other places on market days. The purchase of seeds and commercial fertilizers is generally effected through the associations.

13. Baguio and Manila are the principal markets of the Baguio and Trinidad Valley grown vegetables. Considerable quantities are also shipped to Pampanga, Tarlac, Pangasinan, La Union, Nueva Ecija, and some other provinces.

ILLUSTRATIONS

PLATE I

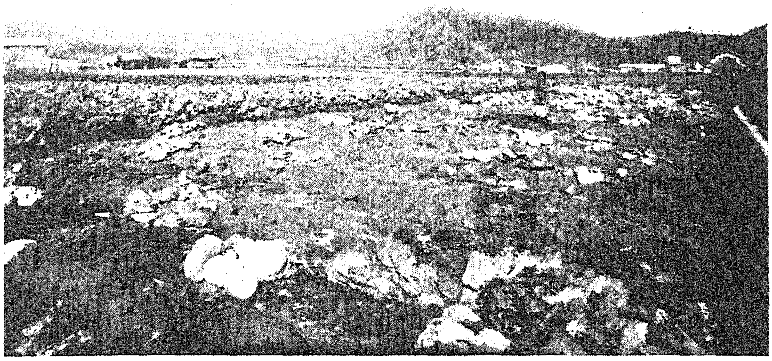
FIG. 1. Portion of the vegetable gardens in Trinidad Valley. In the foreground is a rainy-season cabbage crop just harvested; in the background are dry-season cabbage crops. Raised beds can be seen in the harvested portion of the field.

2. An Irish potato field in Trinidad Valley. An irrigation canal is shown in the foreground, and a compost building on the right.

PLATE II

FIG. 1. Low glasshouses for raising seedlings in Trinidad Valley.

2. Crated vegetables (mostly pechay or Chinese cabbage) ready for shipment to Manila.



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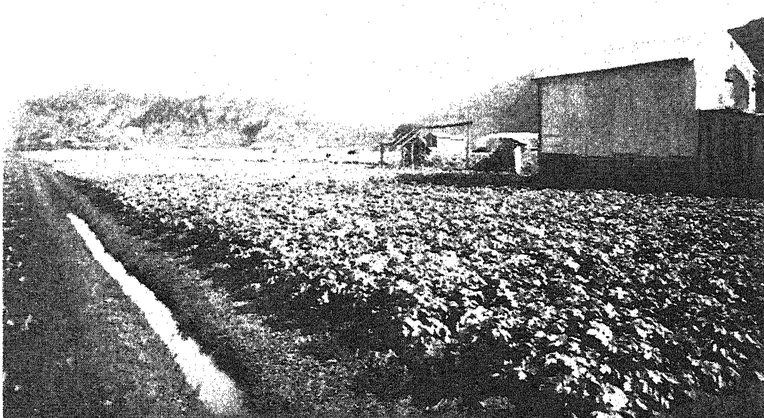

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PLATE I

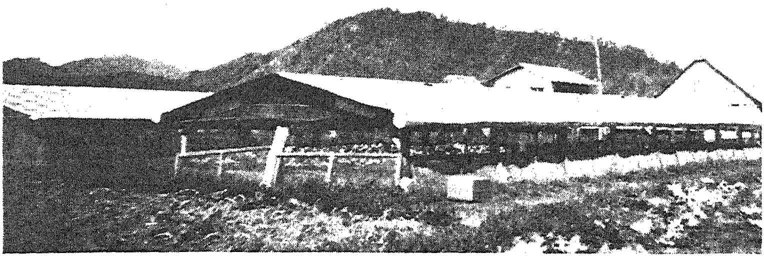

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PLATE II

STUDIES ON THE REFINING OF PHILIPPINE HONEY

By F. T. ADRIANO and S. OLIVEROS

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ONE TEXT FIGURE

Honey, as defined by the United States Department of Agriculture, is the nectar and saccharine exudations of plants, gathered, modified and stored in the combs by honey bees (*Apis mellifica*), is levorotatory, contains not more than 25 per cent of water, with more than 0.25 per cent of ash and not more than 8 per cent of sucrose. The above definition limits the term to the saccharine product through the agency of a definite species of the bee, *Apis mellifica;* thereby excluding the wild Philippine honey from the narrow meaning of the term honey. In the Philippines, attempts to produce honey with *Apis mellifica*, particularly the famous Italian variety (Otanes, 1926), have been made but these attempts never went beyond the experimental and laboratory stage. As far as the authors are aware, the literature, except the circular of Otanes, 1926, is conspicuous by the absence of studies dealing with honey and beekeeping.

According to statistics prepared by the Division of Statistics of the Department of Agriculture and Commerce, the Philippines is importing honey to the value of about 8,000 pesos [1] yearly for direct consumption and for medicinal and confectionery purposes.

In some provinces, particularly Zambales, Bataan, Bulacan, and Rizal, wild honey is collected and may be bought in the local markets or from peddlers.

USES

In ancient times and before the manufacture of sugar was known, honey was the only source of sugar. Then it was a delicacy. Among the Hindus, fresh honey was used as a laxative, and honey that was a year old was used as an astringent.[2] In various countries, honey had its characteristic uses. The *ce-*

[1] One peso Philippine currency equals 50 cents United States currency.
[2] N. C. Dutt., Mat. Med. of the Hindus 1877.

romel of India, for example, made by mixing one part of yellow wax with four parts of fresh honey, was used as mild stimulant in the treatment of ulcers, instead of oils and fats, which grew rancid. In old England, *mead,* a favorite beverage, was made by the fermentation of a liquor obtained by boiling the combs from which the honey was drained. A modification, *sack* or *mead,* had hops in addition to the liquor, to which brandy was added after the fermentation. *Metheglin* or *hydromel* was made by yeast fermentation of a solution of honey with hops. The old Roman *mulsum* was honey, wine and water boiled together. During the time of Chaucer, there was *clarre* or *piment,* a strained solution of honey, wine, water and spices. Among the Arabs, cream or fresh butter with honey was and still is a delicacy eaten with or without bread. Among its other uses may be mentioned that as an embalming agent in Egypt, as purificatory among the Hindus, whereby honey is placed in the mouth of a new-born male infant, and that as a preserving material for shipments of fruits, seeds, and eggs.

In Europe and America, there has been a revival of interest in the use of honey as a part of the diet. The increasing use of manufactured sugar, and the keen interest in the properties of vitamins have led many to advocate the use of honey because of its mineral, nitrogenous, and vitamin contents, which are quite lost in the sugar in the process of manufacture. And although artificial honey can be processed, the composition is at variance with that of genuine honey.

SOURCE AND COMPOSITION

In the United States and in many countries of Europe, notably Hungary, Germany, Poland, Italy, and the Balkans, the production of honey in apiaries is an established trade. In the neighborhood of the Palestine countries—"the land flowing with milk and honey"—the gathering of honey is a source of revenue for the people. In the United States, beekeeping is a science and an art, and the Government lends aid to the industry. In the Philippines, however, honey is simply gathered in the forests.

In apiaries, three recognized classes of honey are gathered; namely, the comb honey or that drained from the comb; extracted honey or honey forced out of combs by centrifugal separators, and shunks, or mixtures of the two. In addition may be mentioned strained honey, gathered by pressing the honey out of the comb and straining until clear.

In the Philippines, as elsewhere, where honey is gathered in the forests, the bees are driven away when the combs are overflowing and preferably before the new brood is started and the honey gathered. The colony is generally smudged in order to drive out the bees.

The locality, season, method of beekeeping, strains of bees, and bee food influence the character of honey. In the United States apiaries in buckwheat fields produce black honeys that are very strong flavored; clover honeys are light in color and alfalfa honeys are amber; the last two are mild in flavor. Heather honey is dark golden yellow; honey from honey-dew is dark. Orange blossom honey has a very fine aroma. The famous Narbonne honey of France is from apiaries in thyme and mint gardens. The Russian *lipez* is honey from linden.

As regards composition, honey is a supersaturated solution in a noncrystallizable sugar of these materials: levulose, dextrose, sucrose, dextrin, gums, ash, pollen grains, beeswax, albuminoids, free acids as malic, chorophyll derivatives, as carotin and xanthophyll, enzymes as invertsase, diastase, amylase, castalase, imulase, aromatic bodies, and vitamins A, B, and C.

Table 2 shows the composition of foreign honeys compared with the average of four samples of Philippine raw honey. There is a decided excessive water content in Philippine honey, and a lack of sugars. It may also be stated that the quality is inferior, fermentation being active in the honeys used in this study.

The samples of Philippine honey were received in old and rusty kerosene cans. The samples were extremely dirty, the dirt consisting of mud, leaves, rotted combs, wax, bodies of dead insects, pieces of jute, and small stones. Granulation was very apparent, some crystallized dextrose being as large as a seed of corn, the crystals being clustered together at the bottom. There was also a frothy scum on top where the insect bodies were floating. Samples capped in bottles without sterilization soon exploded, due to gas during fermentation. The acidity is in fact formic as shown by analysis to be higher than normally expected.

There was also a good deal of suspended matter which made it lack clarity. The collector of the samples stated that they were over a year old. This might account for the fermentation by sugar-tolerant bacteria, the higher acidity, and the scum on top.

It has been established that spoilage may ensue during the storing of honey, caused by the fermentation by sugar-tolerant bacteria. The activity of these bacteria is related to a critical moisture content, about 20 per cent moisture being the limiting line. Long storage, especially of unripe honey, tends to increase moisture, first because of the inherent hygroscropic quality of honey, and second because of the crystallization of dextrose, with one molecule of water of hydration, thus causing the increase in moisture of the non-crystallized portion of the honey.

The black color of three samples analyzed was due probably to natural quality, and partly to the incorporation of soot during smudging and subsequent pressing, and possibly to adulteration with mud and molasses.

The invert sugar was analyzed by the Eynon and Lane method; the water by Brix, the ash by open incineration, according to the Hawaiian methods of sugar analysis, and the acidity by titration with standard alkali, using phenolphthalein.

REFINING OF THE HONEY

The refining of the honey samples presented the following problems: (*a*) The cost of refining had to be low in order that the finished product might be economically marketed; (*b*) the flavor and taste had to be preserved; (*c*) the color had to be reduced to that of ordinary market honey.

All the samples of raw honey were diluted to from 40 to 60° Brix for clarification and decolorization. The following methods were used.

1. *Use of the supercentrifuge* (*laboratory model*).—The honey sample was diluted to approximately 60° Brix and given the following treatments:

(*a*) 1.5 per cent of celite.
(*b*) 3.5 per cent of celite.
(*c*) 1.5 per cent of Kieselguhr.
(*d*) 1.5 per cent of super cel.
(*e*) 1.5 per cent of Spanish clay.

It was found that at 60° Brix, the mixture could not rise up the centrifugal separator, so that the total solids were reduced to 40° Brix. At this dilution, the liquor flowed out of the first discharge (clarifier) but did not separate well. All the centrifuged samples were turbid, due to the suspension of the filter aid.

Excessive dilutions of the honey were not used because the water thus added had to be evaporated again, and every additional quantity of water added would mean additional time and expense of evaporation.

2. *Use of vacuum filtration.*—For honey samples treated at about 45° Brix, attempts were made to effect filtration by the use of a vacuum. A Buchner funnel 6 inches in diameter was attached to a heavy 1-liter suction flask to which was attached a train of two receivers. The filtering media were:

(a) *Asbestos.*—Asbestos prepared for Gooch crucibles was used but this did not give satisfactory results. It was found to be expensive, due to the large area of the Buchner funnel and the fact that it could not be used repeatedly. Aside from this, it was observed that the pores of the Buchner funnel were too large to retain the small fibers, which went into the filtrate; and even if the liquor was filtering clear, at every disturbance of either the vacuum or the feed, asbestos fibers would go into the filtrate and necessitate refiltration. Coating the asbestos mat with a precoat of filter aid did not help any.

(b) *Cloth-filter aid layer.*—The cloth used was ordinary broadcloth cut to fit the Buchner funnel. At first two layers were used; later, only one was employed. The cloth was put in place with the help of water and a layer about 3 millimeters of filter aid was deposited on top. The filter thus prepared was washed free of siliceous material that could be washed down, and used before caking occurred. Caking, due to drying, of the pre-coat of filter aid caused cracks; and the closely packed filter material hindered rapid flow.

The following were qualitative tests:

(1) *Four per cent Spanish clay.*—The filtrate was quite turbid; without change in color. The filter clogged easily. The reason seems to be that the particles of Spanish clay are not uniform in size, and the small ones went into the spaces between the longer ones leaving minute pores or none at all through which the liquor could pass.

(2) *Ten per cent Spanish clay, heated.*—Heating to 60° C. for ten minutes improved the filtering quality somewhat but the color did not get lighter.

(3) *Five per cent Kieselguhr, heated ten minutes at 50° C.*—There was no change in color with two samples, but the clarity was greatly improved.

(4) *Use of decolorizing carbon.*—There was one sample (Raw 4) which could be refined easily and be decolorized to pale yellow. For this sample, without using carbon, the color of the filtrate was dark reddish orange, but was clear and brilliant. For the other samples, however, as much as 20 per cent carbon had to be used, yet it did not materially lighten the color. This seemed to be due to the dirt so closely incorporated with the honey that separation was extremely difficult.

Qualitative tests with the following were made:

(1) Ten per cent decolorizing carbon without filter aid—the filtrate had within it suspended particles of carbon, giving the liquid an ash color; the carbon suspension later settled, but settling was imperfect. Even qualitative filter paper could not hold out the carbon particles of small size.

(2) Two per cent filter aid (Standard Super-cel) and 2 per cent carbon, heated to 60° C. gave good results. This procedure was finally the method adopted, varying the quantity of both carbon and filter aid depending upon the color intensity and turbidity of the syrup.

When the honey was decolorized in this manner, there was an increase in the invert sugars by about 8 per cent due to the removal of suspended matter mostly, and to colloids. It is also possible that heating may have affected some constituents which influence the method of analysis used for invert sugar. The ash also decreased, but the decrease was not much, pointing to the possibility that some of the very fine particles of the filter aid went with the filtrate.

Time and velocity of filtration.—In order to secure balance with the rate of evaporation in an attempt to define a continuous process, the rate of filtration was roughly adjusted. Varying amounts of filter aid were added, and at the same vacuum and the time necessary to filter 3 liters were noted. It was observed that the addition of 0.5 per cent filter aid was not enough to prevent early clogging of the filter used, and that the addition of 1.5 to 10 per cent filter aid gave better results, and varying the amount with the observed turbidity of the sample, the rate was on the average of 6 liters in five hours. The rate seemed to depend upon the precoating of filter aid. A thin precoating caused early clogging, while a thick precoating caused filling up of the funnel with the filter aid. Therefore, a precoat of about 5 millimeters was used throughout the experiment.

Heating to various temperatures was also done. The limits of heating found were ten minutes at 40° C., at which the effect

of the decolorizing carbon was nil, and ten minutes at 80° C., when the syrup darkened even with the addition of sodium carbonate to partially neutralize the acid.

The final heat treatment followed was made at 10 to 15 minutes at 50 to 60° C., never exceeding 65° C.

Another consideration in heating is the loss of volatile matter that makes up the flavor and part of the taste. As was observed, the higher the temperature to which the syrup was heated, the less tasty the resulting syrup is, and even at sterilization temperature, 70 to 75° C., a great deal of the volatile matter is lost, there being a very perceptible difference in the aroma of sterilized and nonsterilized samples from the same stock.

Evaporation.—The decolorized samples were boiled under vacuum to about 75 to 78° Brix. The apparatus, in the final form, is as shown in the sketch. The limiting factor was the capacity of the suction pump, and it was found that at normal tap water pressure this could take care of about 2 kilograms of water vapor at temperatures not exceeding 55° C. and a vacuum not lower than 27 inches, in seven hours. Therefore, the output of the evaporation was about 1 liter per hour when working continuously and in balanced operation. The thick honey was drawn out and dumped into museum jars where two or three charges could be mixed in each before bottling. This was done to make the product similar in every bottle. About

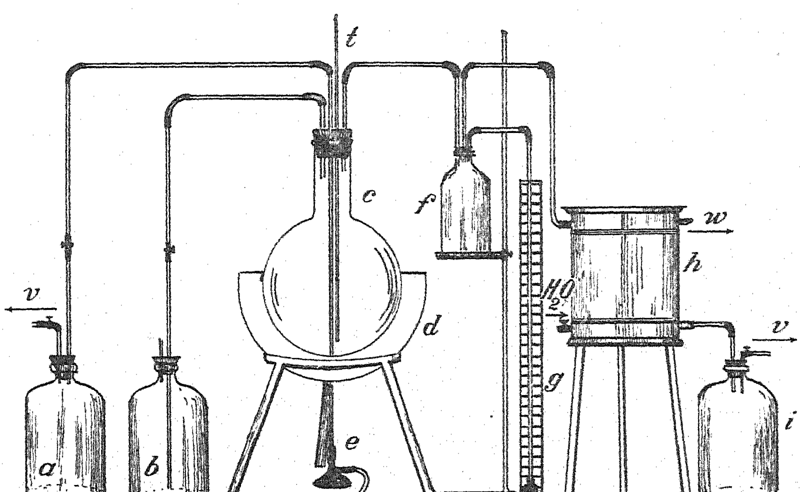

FIG. 1. The assembly of apparatus used for concentrating the diluted and decolorized honey (under vacuum). *a*, Receiver for concentrated honey; *b*, bottle for diluted honey (feed bottle for evaporation); *c*, evaporating flask; *d*, water bath for heating evaporator; *e*, gas burner; *f*, entrainment trap; *g*, mercury manometer; *h*, coil condenser; *i*, distillate receiver; *t*, thermometer; *v*, vacuum; *w*, water.

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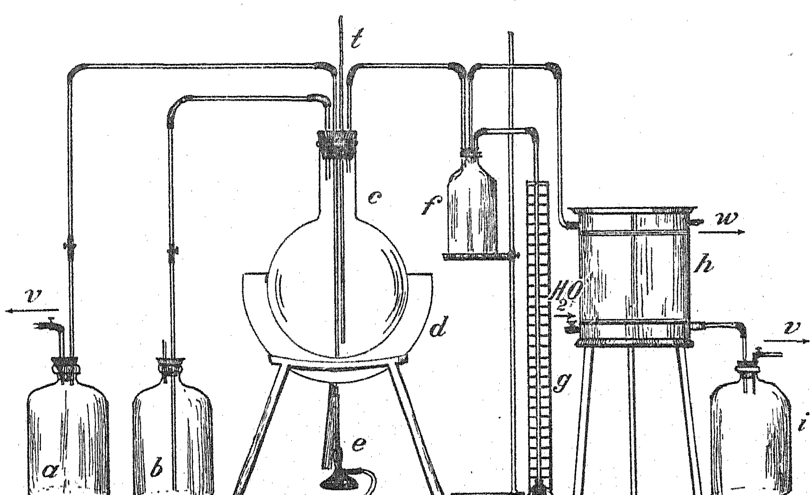

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four grades were produced. The honey was bottled; the bubbles were removed, partly by vacuum and partly by overflow; some bottles were sterilized; some were sealed at once.

The following observations relate to the working of the evaporation:

1. A part of the flavor of the honey was apparent in the condensate. Therefore, the condensate was used as the diluent. This procedure somewhat reduced the loss of aroma in the honey.

2. The flavor and the odor of the honey in this process of refining were ultimately related to the degree of decolorization: the greater the degree of clarification, the more aromatic honey odor and flavor had been removed. Since it is required to produce refined honey of the best flavor possible and having an odor nearest to the original raw honey, the refining could not be carried far enough to get the clarity of commercial-grade honey.

3. Some bottles of the refined honey showed reddening or browning at the top. This may have been due to the colloidal suspension floating where the lightest portion of the honey is, and to oxidation (Cruess) on that place in the surface.

4. The first portion of the honey drawn into the evaporators stays in these for about six hours or until the charge is drawn out. The prolonged heat treatment may modify the character of the honey; especially during the last stage of evaporation where, due to the concentration and viscosity of the syrup, the stirring was insufficient for thorough mixing.

COST OF REFINING

Table 4 shows the cost of refining the honey in the laboratory. The cost can be greatly reduced if the decolorizing carbon can be reclaimed by incineration out of contact with air, as is done in sugar refineries. The use of properly designed evaporators and preheaters [1] is also important.

The price of honey in the United States during normal times is about 10 cents per pound. It is manifestly impossible with present methods to compete with American honeys, except those that are packaged in fancy style.

SUMMARY

The usual grade of raw Philippine honey as commonly bought in the markets is dirty and quite frequently in a fermenting stage. The dirt usually consists of black suspended material,

[1] Elec. World 88 (1926) 1123–24.

dead bees, leaves, twigs, and mud. The suspended material cannot be removed by ordinary filtration. Even the best grade of raw Philippine honey cannot be used for confectionery purposes. After refining, this same honey has been found to be satisfactory.

Filtration of diluted honey with the help of filter aids effects clarification to a certain extent. Due to colloids and other suspended matter, the filtration is very difficult.

The use of decolorizing carbon decolorizes honey with different degrees of facility. Some samples of raw honey can be decolorized more easily than others.

Heating removes a goodly portion of the aroma of honey. Prolonged heating at high temperatures darkens the color. It seems that the characteristic taste and odor of Philippine honey varies with the extent of refining; that is, the greater the degree of clarification, the more aromatic odor is driven off.

The laboratory method of refining honey is too expensive. If done on a large scale and with cheaper decolorizing carbons similar to those used in the refining of sugar, the cost of refining would be greatly reduced.

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TABLE 1.—*Quantity and value of honey imported into the Philippine Islands*

Year	Quantity	Value
	Kg.	*Pesos*
1928	13,466	10,332
1929	14,640	10,455
1930	9,289	6,594
1931	12,823	6,263
1932	....	4,951
Average	....	7,719

TABLE 2.—*Showing chemical composition of Philippine raw and refined honey compared with that of foreign honeys*

Origin	Water	Invert sugar	Sucrose	Ash	Dextrin	Acid	Source
America	17.70	74.98	1.90	0.18	1.51	0.08	Browne.
Cuba	21.07	71.77	0.94	0.22	1.43	0.14	Bryan.
Mexico	21.04	72.30	0.80	0.25	1.45	0.19	Do.
Haiti	22.02	73.73	0.55	0.16	0.53	0.12	Do.
Spain	20.60	72.88	1.76	0.25	1.69	....	Encyclopaedia Universal.
Philippines; raw	28.90	58.56	....	0.35	....	0.19	Analyzed.
Philippines; refined	25.97	66.97	....	0.28	....	0.20	Do.

TABLE 3.—*The chemical composition of raw and refined Philippine honeys*

Sample	Brix	Invert sugar	Ash	Acid	Color	Turbidity at 50° Brix
	°					
Raw 1	68	55.64	0.43	0.216	Black	10
Raw 2	71.5	57.24	....	....	....do	10
Raw 3	70	56.46	....	....	....do	10
Raw 4	75	64.92	0.27	0.166	Burnt red	10
Filtered 1	50	44.65	....	....	Clear red	80
Decolorized 1	75	67.64	....	0.207	Clear reddish orange	103
Decolorized 2	73	66.24	....	....	Clear red	114
Decolorized 3	75	67.03	0.28	....	Bright yellow	142
Filtered from raw 4	50	....	....	0.179	Dull burnt red	80

TABLE 4.—*Observations on clarification of Philippine honey*

Original sample			Filter aid		Heating		Decoloriz-ing carbon [a]
Brix	Color	Turbidity	Name	Quantity [a]	Temp.	Time	
°					°C.	*Min.*	
40	Burnt brown	Very turbid	Celite	1.5			
40	do	do	do	3.5			
40	do	do	Kieselguhr	1.5			
40	do	do	Super cel	1.5			
40	do	do	Spanish clay	1.5			
40	do	do	Super cel	2	60		
50	do	do	do	1.5	60		
50	do	do			60	30	10
50	do	do	Spanish clay	4			
50	do	do	do	10	60	10	
50	do	do	Kieselguhr	5	50	10	
50	do	do	Super cel	2	70	5	2
50	do	do	do	2	60	10	2
40	do	do	do	2	60	10	2
40	do	do			80	5	2
40	Reddish brown	Turbid	Super cel	2	65	10	2

Orginal sample			Treated sample		Method of separation	Filtering rate	Remarks
Brix	Color	Turbidity	Clarity	Color			
40	Burnt brown	Very turpid	Turbid	No change	Supercentrifuge		
40	do	do	Very turbid	do	do		
40	do	do	Turbid	do	do		
40	do	do	do	do	do		
40	do	do	do	do	do		
40	do	do	do	do	Asbestos mat	Slow	Filter easily clogged.
50	do	do	Little turbidity	do	Cloth filter	Two-thirds liter per hour	
50	do	do	Carbon suspension		Sugar filter paper	Very slow	No filter aid.
50	do	do	Turbid	No change	Cloth filter	Clogged early	
50	do	do	Little turbidity	do	do	Moderately fast	Funnel filled.
50	do	do	Clear	do	do	One-half liter per hour	
50	do	do	do	Brownish yellow	do	do	
50	do	do	do	do	do	do	
40	do	do	do	do	do	Two-thirds liter per hour	
40	do	do		Black			
40	Reddish brown	Turbid	Clear	Bright yellow	Cloth filter	do	

[a] Expressed as per cent by weight of syrup.

TABLE 5.—*Cost of refining raw honey in the laboratory. Cost per kilo of 73–75° Brix*

	Page
Filter aid	0.01
Decolorizing carbon [a]	0.12
Gas	0.12
Water	0.05
Total	0.30
Cost per pound	0.14
Cost per liter	0.40

[a] The cost can be very greatly reduced if the decolorizing carbon is reactivated or steam is used instead of city gas. Decolorozing carbon (Germann and Co.) cost 1.30 pesos per kilo.

ILLUSTRATIONS

TEXT FIGURE

FIG. 1. The assembly of apparatus used for concentrating the diluted and decolorized honey (under vacuum).

a, Receiver for concentrated honey.
b, Bottle for diluted honey (feed bottle for evaporation).
c, Evaporating flask.
d, Water bath for heating evaporator.
e, Gas burner.
f, Entrainment trap.
g, Mercury manometer.
h, Coil condenser.
i, Distillate receiver.
t, Thermometer.
v, Vacuum.
w, Water.

PREPARATION OF VINEGAR FROM PHILIPPINE FRUITS AND OTHER SACCHARINE MATERIALS

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Vinegar has been defined as a "condiment produced by the successive alcoholic and acetic fermentation of a watery solution of sugar or starchy substances containing yeasts and bacteria." It comes from the French words "vin aigre" meaning sour wine. Its use as a food commodity is universal.

The European and American standard vinegars are prepared from apple and grape juices. Recently, however, vinegar has been made from other temperate as well as subtropical fruits, such as pears, peaches, persimmons, oranges, watermelons, berries, and bananas. In the Philippines vinegar is made from the toddies of nipa, coconut, buri, and cabo negro, and from sugar-cane juice.

The seasonal occurrence of many fruits in the Philippines has created problems of varied interest and importance among the farmers, the most neglected of which is perhaps how properly to utilize the great amount of waste of fruits that accompany each harvest. Aside from the tuba, nipa, and other palm toddies as the usual local sources of vinegar, different varieties of bananas and fruits have been found to contain high fermentable sugars, which render them fit for wine and vinegar making.

The waste consists principally of fruits that cannot be profitably marketed, due to bruises caused by mishandling or overripeness; or that, because of oversupply, cannot be sold at profitable prices in the local markets.

The value of vinegar imported into the Philippines during five recent years is shown in Table 1.

TABLE 1.—*Value of Philippine vinegar imports from 1927 to 1931*

Year	Liters	Pesos
1931	75,300	14,584
1930	55,180	10,557
1929	58,827	14,116
1928	86,141	19,239
1927	73,765	16,863
Average	69,765	15,152

This importation could be greatly diminished if in many homes vinegar could be properly made from fruits and juices heretofore thrown away as waste.

USES OF VINEGAR

The importance of vinegar as an article in food preparation and preservation cannot be overestimated, as it is used in seasoning foods prepared from meat, fish, and vegetables of all kinds. It is indispensable in the household.

Vinegar is a constituent of high-quality catsups, salad dressings, mayonnaise (sometimes), prepared mustard, and many sauces. It helps in preventing foods from spoilage.

Vinegar has a place of its own in the pickling industry. Pickles of different kinds are good appetizers and for their preparation vinegar is the most important ingredient.

REVIEW OF LITERATURE

Von Loesecke (1929) reported that bananas contain on the average about 16 per cent fermentable sugars. The alcohol content during fermentation varies from 6.55 to 10.12 per cent. The banana vinegar obtained by the Orleans process was light amber in color and possessed an agreeable aroma and taste.

Van Slyke (1904) reported that the alcoholic fermentation of cider kept at a cellar temperature of 7.2 to 12.7° C. was completed in about five to six months. The acetic acid fermentation then followed and was complete in a period varying from fifteen to twenty-four months. It was concluded by Van Slyke that the acetic fermentation proceeded more rapidly and satisfactorily at a temperature ranging from 10 to 32.2° C. than from 7.2 to 18.3° C. A total acid content of from 4.3 to 7 per cent was obtained in six months, but the results were not uniform. It was also concluded that adding "mother of vinegar" when the alcoholic fermentation was about complete hastened the completion of the acid fermentation. There was a loss of acetic acid in old vinegar which resulted from contamination with organisms that destroy the acid in the presence of air.

Lamb and Wilson (1923) demonstrated that with apples it is possible to make good cider vinegar in twelve months or less. In many cases the vinegar reached a marketable strength in less than six months. They have further shown that the alcoholic fermentation is nearly made complete in one month or less and the formation of acetic acid begins in two or three weeks after the juice is pressed from the apples.

Adriano and Banzon (1931), in their work on the preparation of vinegar from fruit juices and palm toddies, found that the Latundan variety of banana contained over 5 per cent acetic acid and possessed a very pleasing aroma. They further demonstrated that the vinegar from water of immature (*buco*) coconuts contained about 1 per cent acetic acid; the nipa vinegar commonly sold in the local stores, 2 per cent; and artificial vinegar now commonly sold everywhere, 4 per cent.

OBJECT OF THE WORK

The present work has for its object the determination of the proper methods of preparing vinegar from fruits and juices that abound in many places and can furnish cheap raw materials for this product. The work has not been carried beyond the laboratory scale but could be expanded to commercial scale production.

PRINCIPLES INVOLVED IN THE PREPARATION OF VINEGAR

ALCOHOLIC FERMENTATION

The process consists in the conversion of the sugar into alcohol and carbonic acid gas, through the action of the microscopical one-celled plants called yeasts.

The following reaction takes place when the sugar of the fermenting solution is acted upon by yeasts:

$$C_6H_{12}O_6 + \text{Yeasts} = 2C_2H_5OH + 2CO_2$$

Chemically, this means that 100 parts of sugar should give theoretically 51 parts of alcohol and 49 parts of carbon dioxide; whereas practical tests show a yield from 48.5 to 50 parts of alcohol.

The fruit mash is treated with commercial yeast that has been mixed with a small portion of the juice. The receptacle is covered with a layer or two of cheesecloth to prevent the entrance of insects. During fermentation the mash is stirred daily to prevent mold formation and insure a more complete fermentation. The action of acetic bacteria is also prevented by stirring. Three or more days are necessary for this fermentation.

The fermented juice is separated from the mash by filtration through a piece of cheesecloth. Complete separation requires the use of a hand press. The alcohol content is determined according to the methods of the Association of Official Agricultural Chemists (1930). The alcohol test is not essential and is

seldom made except in the laboratory and in the commercial production of vinegar.

ACETIC FERMENTATION

After the fermented juice has been returned to the jar or barrel, a starter in the form of strong, fresh vinegar is added in the proportion of 1 part to 4 parts of the fermented juice and the receptacle covered with cheesecloth.

The addition of vinegar will introduce sufficient acetic bacteria to promote the acetification. The rapid development of bacteria produces a slimy skin or film known as "mother of vinegar." This coating is essential for a successful fermentation and it will form and settle as long as any alcohol remains in solution.

The following show the changes that take place during acetic fermentation:

$$\underset{\text{Alcohol}}{C_2H_5OH} + O = \underset{\text{Aldehyde}}{C_2H_4O} + H_2O$$

$$C_2H_4O + \text{acetic bacteria} + O = \underset{\text{Acetic acid}}{CH_3COOH}$$

The alcohol is changed by oxidation into a product called aldehyde (acetic aldehyde) and the aldehyde is acted upon by the acetic bacteria to form acetic acid.

The vinegar fermentation is carried on by one or the other of the following described processes:

Slow process.—Of the so-called slow processes, the Orleans method of acetification is the best. This process is carried on in barrel containers holding about 100 or 150 liters and it takes several months to complete the fermentation. The barrels should be filled about three-quarters full. Bungholes, about an inch in diameter, should be bored to permit the free circulation of air. They should be screened with woven wire or cheesecloth to keep out insects. The barrels should not be disturbed during the acetous fermentation. The vinegar is allowed to stand until it has reached its maximum strength. Approximately three-fourths of the prepared vinegar can be drawn off and to the remaining fourth newly fermented and settled juice can be added to start a new acetic fermentation.

Generator process.—The greater the amount of air supplied to the vinegar bacteria, the faster is the rate of vinegar fermentation. Therefore, the rate of acetification is increased when more oxygen is introduced by using the so-called generator process.

Two types of generators are in use. The first is the "tank generator," which is provided with false bottoms, containing

beech-wood shavings, birch twigs, corn cobs, or other inert woody materials, previously saturated with old vinegar, through which the alcoholic liquor percolates and is brought in contact with a current of air introduced from below.

The other is called the "rotating generator," which is provided with false bottoms, containing the alcoholic liquor into which dip slowly revolving drums containing beech shavings. In the former process the acetification is completed in two or three days; in the latter, in about four weeks.

AGING

The highest quality of vinegar is attained by storage from six months to a year or more. During storage the biting taste of a new product is turned mellow, the esters are formed, and the flavor and aroma of good vinegar become distinctly apparent.

CLARIFICATION

Racking off the liquid.—The vinegar is "racked off," that is, drawn off carefully, after several months of storage, so as not to disturb the sediment and with as little exposure to the air as possible. This is satisfactorily done with the use of a siphon. Ordinarily, the yield is clear and fit for home use but when intended for sale it should be clarified.

Filtration.—Filtration of vinegar is the most common method of obtaining a clear product.

The liquid is passed through a filter made by folding a piece of canton flannel or cheesecloth into two or three thicknesses. The efficacy of all filters depends upon the gradual filling up of the pores of the filtering medium by particles of the material passing through it. Perfect clarification is accomplished only by repeated filtration.

Clarifying agents.—Some clarifying agents used in securing a clear or bright product are the "Standard Super-cel," Spanish clay, Kieselguhr, etc.

Kieselguhr, a compound of silica, is applied at the rate of from 0.75 to 1.0 per cent of volume of the highly colored liquids.

Spanish clay and the "Standard Super Cel" are applied in varying amounts from 0.75 to 1.5 per cent of the volume of more or less light colored liquids.

After treatment with clarifying agents, the mixture is heated to 60° C., settled, and filtered.

Clarifiers are substances which facilitate the removal of suspended matter in the turbid liquid. They are porous, light in

weight, inert, and do not affect the physical or chemical characteristics of the filtrate. They have a rather low specific gravity so that they remain in suspension while the liquid is being filtered.

Removal of blue-black discoloration.—The blue-black color of vinegar is mainly due to a combination of tannin compounds and iron which is usually introduced through contamination with water and the equipment used.

Kreipe (1932) recommends the use of gelatin in the proportion of 2 to 4 grams per 100 liters of the vinegar. The gelatin is first dissolved by heating in a small amount of vinegar. It combines in part with the tannin and gradually flakes out. These flakes settle to the bottom. After some days the clarification is finished and when the sediment has settled, the clear supernatant liquid can be carefully drawn off.

Packing or bottling.—When the vinegar has been aged and clarified it can be bottled in suitable containers. Commercially, the product is put in bottles, sealed, and pasteurized. For home use, it can be kept in containers that have been steamed or sterilized. The finished product is kept in a cool room or cellar.

Pasteurization.—Pasteurization has for its object the preservation and maintenance of the strength of vinegar. Microorganisms that are responsible for the deterioration of the product are killed at temperatures ranging from 60 to 71° C.

Vinegar is usually pasteurized in loosely corked bottles or other suitable containers by submerging the same in tanks of water heated to proper temperatures for about 20 to 30 minutes.

MATERIALS USED

Of course none of the materials used were unripe, rotten, or decayed, since decayed and dirty materials impart an unpleasant and undesirable flavor or aroma to the resulting product. Only fully ripe and sound fruits, raised at the Lamao Horticultural Station of the Bureau of Plant Industry, were used in the experiments. The nipa sap was furnished by Mr. Francisco Marasigan, of Paombong, Bulacan.

1. Varieties of bananas used. Bananas (*Musa sapientum* L.).
   Varieties used for preparing single samples of vinegar: Ideep, Morado, Morong Datu, Tembotok.
   Varieties used for preparing the mixed samples of vinegar: Katali, Lacatan, Latundan, Tiparot, Saba, Toybok.
2. Sap of nipa (*Nypa fruticans* Wur.).
3. Water from coconut (*Cocos nucifera* L.).

4. Fruits:
   Perunkila (*Carissa carandas* L.).
   Lipoti (*Eugenia curanii* C. B. R.).

Other fruits containing a sufficient amount of fermentable sugars can also be used for preparing vinegar.

EXPERIMENTAL

VINEGAR FROM BANANAS

Process.—Seven varieties of bananas, such as the Ideep, Morado, Morong Datu, and Tembotok, were used for single determinations. For purposes of differentiation and comparison, mixed mashes were also made out of Katali, Lacatan, Tiparot, Saba, and Toybok.

Bananas contain an average of about 18 per cent fermentable sugars. The peel and pulp, when ground, gives a thick and viscous mash which prevents a thorough incorporation of the yeasts. About an equal amount of water is added to the mash to make it semifluid and then sufficient sugar is added to bring the sugar content up to about 15 per cent.

The Morado bananas, weighing 683.3 grams, were passed through a meat grinder and then mixed with about an equal amount of water and 125 grams of sugar. The resulting mixture had around 16 or 17 per cent sugar, or enough to produce vinegar of about 7 per cent acetic acid. About 250 cc. of yeast starter was added and the whole set aside in a 3-liter glass jar having a wide mouth. The jar was covered with cheesecloth to prevent the entrance of flies and other insects. Fermentation set in within a day and continued for about two weeks. Alcoholic fermentation was recognized by the continuous evolution of small bubbles of carbon dioxide gas. The pulp was buoyed up by the escaping gas during the fermentation and thus the solids were mechanically separated from the liquid portion. The mash was stirred now and then to promote a thorough alcoholic fermentation.

TABLE 2.—*The alcohol content of the fermented banana juice*

Serial No.	Material	Specific gravity; 25°/25°	Alcohol; per cent by weight	Sugar; per cent alcohol by weight x 2
CI	Morado	0.98730	7.38	14.76
CII	Tembotok	0.98178	11.07	22.14
CIII	Ideep	0.98571	8.38	16.76
CIV	Morong Datu	0.98612	8.14	16.28
CV	Mixed mash	0.98039	11.96	23.92

The completion of alcoholization was indicated by the decreasing production of gas bubbles. This took place in about two weeks. The liquid was then strained through cheesecloth. The alcohol content was determined by the pycnometer method. The results are shown in Table 2. About 300 cubic centimeters of good fresh strong nipa vinegar was added to start acetification. The container was left undisturbed. A film of "mother vinegar" or mycoderma aceti was rapidly formed on the surface, indicating rapid development of acetic bacteria. The acetic acid content was determined from time to time by titration with the use of a standard alkali solution. The results are shown in Table 3.

The same process was followed with the other varieties determined. For Tembotok, the sample used was 762.4 grams, for Ideep, 1,124.4 grams, and for Morong Datu, 610 grams. The results are shown in Table 3.

Mixed mashes consisting of the peel and pulp of Katali, Lacatan, Latundan, were also made. The same method as that followed for the Morado was used. The results are given in Table 3.

TABLE 3.—*Rate of acetification of banana cider*

Age		Acetic acid				
Date	Days	Morado	Tembotok	Ideep	Morong Datu	Mixed mash
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
October 21, 1932		2.18	1.92	2.29	1.15	2.50
October 26, 1932	5	2.26	2.29	2.40	2.20	2.82
November 2, 1932	13	2.38	2.45	2.58	2.80	3.31
November 7, 1932	18	2.43	3.35	2.79	3.38	3.78
November 12, 1932	23	3.48	3.79	3.49	3.79	4.52
November 17, 1932	28	3.84	4.51	3.76	4.08	5.28
November 22, 1932	33	4.22	5.24	4.37	4.51	5.89
November 28, 1932	39	4.36	5.53	4.73	4.87	6.42
December 3, 1932	43	4.36	5.52	4.73	4.84	6.42

VINEGAR FROM NIPA SAP

(*Nypa fruticans* Wur.)

Process.—The experiment on the production of vinegar from the sap of nipa was carried on in two parts (Parts I and II). Part II was started a month earlier than Part I.

Part I was divided into four samples using equal amounts of the sap.

Sample A, containing about 3 liters, was neutralized with calcium carbonate, then heated to boiling, cooled and fermented with the use of the commercial yeast. The treatment with

calcium carbonate had for its object the neutralization of the small amount of acetic acid present in the sample, that would interfere with proper fermentation of the sample. Heating kills the organisms that may cause deterioration of the product. The commercial yeast was first dissolved with a little nipa juice before applying it to the whole sample. The alcoholic fermentation was completed in about a week. Acetification was started by adding 800 cubic centimeters of the nipa vinegar. The acidity was determined once a week. The results are shown in Table 4.

TABLE 4.—*Part I. The rate of acetification of nipa vinegar*

Age		Acetic acid			
Date	Days	Sample A	Sample B	Sample C; control	Sample D
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
November 2, 1932	....	2.91	3.34	3.68	1.41
November 7, 1932	5	3.13	3.43	3.72	1.18
November 12, 1932	10	3.42	4.74	4.20	2.50
November 17, 1932	15	3.45	4.87	4.52	2.85
November 22, 1932	20	4.01	5.36	4.97	3.73
November 28, 1932	26	4.00	5.38	4.97	3.70
December 3, 1932	31	4.00	5.35	4.97	3.70
December 8, 1932	36	4.00	5.35	4.92	3.60

Sample B, using the same amount as Sample A, was heated to boiling, cooled, and fermented with the use of yeast. The acetification was subsequently followed. The acidity was also determined.

Sample C served as control.

Sample D was heated to boiling with 12 cubic centimeters of 6 per cent sulphurous acid, heated to boiling, cooled, and fermented with the use of commercial yeast. The sulphurous acid treatment prevents the growth of vinegar eels, molds, and other microörganisms. The results are shown in Table 4.

Part II. Another batch of nipa sap was divided into three samples.

Sample A, in which two 1-liter bottles were filled with vinegar, pasteurized at 65° C. for thirty minutes, stoppered with a cork and sealed with paraffin. The acidity was determined on the first and last days of observations.

Sample B, in which two 1-liter bottles were filled with the sap and plugged with cotton. This was not pasteurized.

Sample C, divided into Sample C_1, contained about one-third of the liquid contents, C_2 contained three-fourths, Sample C_3 was filled with the liquid to the neck.

The same processes of alcoholic and the subsequent acetous fermentations were observed. The bottles were kept in a cellar with a temperature ranging from 24 to 26° C. The results are shown in Table 5.

TABLE 5.—*Part II. The rate of acetification of nipa vinegar*

Age		Acetic acid				
Date	Days	Sample A	Sample B	Sample		
				C_1	C_2	C_3
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
September 24, 1932	....	2.46	3.32	2.97	3.45	3.02
October 1, 1932	7	....	3.60	3.02	3.03	2.99
October 8, 1932	14	....	3.64	3.28	3.08	3.08
October 15, 1932	21	....	3.76	3.30	3.14	3.07
October 22, 1932	28	....	4.35	3.59	3.17	3.07
October 29, 1932	35	....	4.36	4.65	3.08	3.08
November 5, 1932	42	....	4.34	4.66	3.12	3.11
November 12, 1932	50	....	4.34	4.64	3.08	3.11
November 21, 1932	89	3.06	4.27	4.11	3.57	3.09

VINEGAR FROM COCONUT WATER

Process.—The water obtained fresh from mature nuts was placed in a wide-mouthed glass jar of two liters capacity. Commercial yeast, previously dissolved in some coconut water, was added to the sample. Within 12 hours the liquid was fermenting very rapidly. The evolution of gas bubbles was vigorous in about two days. Stirring of the contents helped in the formation of alcohol. When alcoholization had ceased, the sample was inoculated with nipa vinegar to start the acetification. The rate of acetification was determined by titration with standard alkali at frequent intervals. The results are shown in Table 6.

TABLE 6.—*Maximum acidity developed by coconut water and fruits*

Material	Acetic acid Per cent
Coconut water	3.00
Perunkila	4.00
Lipoti	5.23
Bananas:	
Morado	4.36
Tembotok	5.53
Indeep	4.73
Morong Datu	4.87
Mixed banana mash	6.42

VINEGAR FROM FRUITS

Process.—Only two kinds of fruits were used, namely, the Perunkila and Lipoti. They were considered as waste after having become over-ripe. By following similar processes to

that used in the preceding experiments, vinegar was also obtained from these fruits. The results are shown in Table 6. Many other Philippine fruits could be used for vinegar making in the homes and on the farms.

V. RESULTS AND DISCUSSION

The results are shown in Tables 2 to 6. As shown in Table 2, the alcohol content of fermented banana juice varies from 7.38 per cent for the Morado variety to 11.96 per cent of the mixed mash. Of the singly determined varieties, the Tembotok gives the highest with 11.07 per cent.

The approximate sugar content of the original juices is found by multiplying the per cent by the weight of alcohol by 2.

Table 3, gives the average per cent of acidity of the banana cider. It may be noted that the mixed mashes give a higher percentage of acidity than any of the separately determined varieties. The maximum was reached on the 38th day with 6.42 per cent. Adding to this about two weeks for alcoholization, the total period from the beginning to the maximum production of acidity, would be 52 days. Of the separately determined varieties the Tembotok gave the highest, with 5.33 per cent.

In general, however, the banana vinegar produced gave percentages of acidity which are well over the legal standard of 4 per cent.

The banana vinegar obtained retained the aroma of the original substance. It is clear and pale brown.

The rate of acetification of the nipa vinegar is shown in Tables 4 and 5. The maximum acidity was reached on the twentieth day for sample A, C, and D and on the 26th day for sample B. Excepting sample D, in which sulphurous acid was used, which may have retarded the acetification somewhat, all the rest developed fairly high percentages of acidity. The control came next to sample B for acetic acid content. Evidently, the heating process may have eliminated the destructive or undesirable microörganisms in the liquid so that the acetification developed favorably.

Table 5 shows the rate of acetification of nipa vinegar in bottles kept in a cellar with a temperature ranging from 24° to 26° C.

Sample A, which was kept in sealed bottles, did not develop a high percentage of acidity, the average range being from 2.46 to 3.06 per cent. This had its parallel results with bottles C_3

of sample C which were filled to capacity, and which gave 3.11 per cent acetic acid.

Moreover, sample B, which was in a bottle plugged with cotton developed a high acetic acid content of 4.27 per cent. Sample C_1, which contained the least amount of vinegar, developed a higher per cent acidity of 4.11 per cent than that of the sample C_3 where the bottles were filled to capacity.

Table 6 shows the acidity developed by the coconut water and fruits. The water of coconut gave only 3 per cent. This may be accounted for by the fact that coconut water contains low per cent sugar. The Perunkila and Lipoti gave per cent acidities of 4 and 5.23, respectively. The single varieties of bananas gave an average of 4.87 per cent while that of the mixed mashes gave 6.42 per cent.

SUMMARY

1. The banana varieties studied for preparing single samples of vinegar, were the Ideep, Morado, Morong Datu, and Tembotok; for the mixed samples, Katali, Lacatan, Latundan, Tiparot, Saba and Toybok.
2. The fruits studied were the Perunkila and Lipoti, and the palm toddies were nipa and coconut water.
3. The alcoholic and its subsequent acetic fermentation was carried on at the ordinary room temperature, ranging from 26.5° to 35° C., except for Part II of the nipa vinegar where a temperature of from 24° to 26° C. was maintained.
4. The banana cider of the mixed mash gave a higher per cent alcohol by weight than any of the individual varieties determined. Likewise, in the acetic fermentation, the mixed banana mash gave a higher per cent of acetic acid.
5. In general, the banana vinegar produced in this experiment gave percentages of acidity higher than the legal standard of 4 per cent. It retained the aroma of the original substance, and was a clear, pale brown.
6. When the nipa sap is first heated to boiling then cooled and subsequently fermented and acetified, a higher per cent of acetic acid is produced in the resulting vinegar.
7. Fruits such as the Perunkila and Lipoti produced vinegars of 4 and 5.23 per cent acetic acid, respectively.
8. The coconut water, because of its low content of sugar, gave a vinegar of low acetic-acid content.
9. Methods of preparing vinegar from fruits and saccharine juices were described.

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CHARACTERISTICS OF PHILIPPINE VINEGARS [1]

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Vinegar is a commodity indispensable in every household. It finds extensive use in the pickling of vegetables and fruits. The characterictics of foreign vinegars, the American, for example, have been extensively studied in order to establish standards of purity and safe-guard the public from fraud.

Philippine vinegars, however, have been little studied. A few analyses have been made in the course of investigations pertaining to alcohol manufacture. Thus, Gibbs (1911) reported the analyses of three samples of nipa vinegar; the total solids, ash, phosphorus pentoxide, acetic acid, alcohol were determined; and analyses of five samples of coconut vinegar were also given.

The present study was made to find out the characteristics of native vinegars and to compare them with those of foreign manufacture.

MATERIALS AND METHODS

The common Philippine vinegars may be classified according to their origin as follows:

1. Palm vinegars.
    - (*a*) Cabo negro or kaong.
    - (*b*) Coconut.
    - (*c*) Nipa.
    - (*d*) Buri.
2. Cane-juice vinegars.
    - (*a*) Straight.
    - (*b*) Basi.
3. Artificial vinegar prepared from glacial acetic acid.

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[1] Read before the Los Baños Biological Club, February 25, 1932.

[2] Formerly Associate Professor of Chemistry, College of Agriculture, University of the Philippines.

Fruit juices are also sources of vinegars, but are rather rare. An insight into the method of manufacture aids in the interpretation of the analyses. The native method of preparation is invariably reduced to one method, which is spontaneous fermentation. In the case of palm and cane-juice (straight) vinegars, the procedure is to place the collected sap or juice in containers (usually large earthenware jars called *tapayan*), cover them with wooden slabs, and set the containers aside while the liquid ferments spontaneously. The vinegar is considered ready for consumption when it is sour enough to the taste. The product thus obtained is usually turbid or opalescent, slightly aromatic, and with a pronounced acetic-acid odor.

Basi vinegar may be considered as an accidental product in the preparation of the alcoholic beverage known as basi. This drink is made by boiling sugar-cane juice until it is almost two-thirds its original volume and fermenting the resulting syrup. Fermentation takes place spontaneously. As is well known, the sugar is first acted upon by yeast, forming alcohol. This is the process desired in the manufacture of alcoholic beverages. Some microörganisms, however, may act on the alcohol as soon as formed and convert it into acetic acid. This second stage of fermentation is not desired in the making of a beverage inasmuch as the acid taste is displeasing; also, when sufficient acetic acid accumulates, the formation of alcohol diminishes to such an extent as practically to stop it altogether. Although useless as a drink, the acetified liquor thus produced may be used as a vinegar. This is the origin of basi vinegar.

Artificial vinegar is pure acetic acid diluted with water so as to contain 4 per cent of the acid, and colored with burnt sugar (caramel) to an amber liquid.

Samples of these different kinds of vinegars were obtained from several localities for analysis. Following the methods of the Assocation of Official Agricultural Chemists, the following constituents were determined: specific gravity, acidity, total and soluble solids, total and soluble ash, alkalinity of soluble ash, phosphorus pentoxide in the soluble ash, and reducing sugars. The acidity and aroma are of prime importance, but while the acidity may be measured, there is no quantitative method of estimating the flavor. The other constituents determined show the character of the sample and are of value in fixing standards of purity, and in ascertaining adulteration.

TABLE 1.—*The chemical composition of some Philippine vinegars*

	Specific gravity	Acetic acid	Solids			Total ash	Soluble ash
			Total	Dissolved	Suspended		
	28°/28°C.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
I. Cabo negro toddy:							
1. Batangas Province, Tanauan	1.0084	2.76	1.73	1.14	0.57	0.51	0.43
II. Coconut toddy:							
1. Laguna Province, Bay	1.0136	1.87	5.02	4.63	0.39	0.46	0.40
2. Tayabas Province, Lucena	1.0041	2.28	2.27	2.16	0.11	0.52	0.45
Average	1.0089	2.08	3.65	3.40	0.25	0.49	0.43
III. Nipa vinegar:							
1. Bataan Province, Balanga	1.0098	2.96	2.27	2.14	0.13	0.97	0.90
2. Batangas Province, Tanauan	1.0113	2.38	1.90	1.74	0.16	0.82	0.67
3. Bulacan Province, Malolos	1.0120	3.00	2.43	2.23	0.20	0.72	0.64
4. Cavite Province, Tanza	1.0107	2.95	3.01	2.38	0.63	0.85	0.81
5. Laguna Province, Los Baños, coconut grove A	1.0038	0.87	0.55	0.28	0.27	0.24	0.22
6. Laguna Province, Los Baños, coconut grove B	1.0091	2.01	0.91	0.55	0.36	0.43	0.38
7. Laguna Province, Los Baños, Tong Store	1.0045	1.67	0.96	0.86	0.10	0.36	0.34
8. Manila, Sibacong	1.0108	3.66	1.93	1.63	0.30	0.76	0.73
9. Tarlac Province, Victoria	1.0056	1.33	0.79	0.79	....	0.39	0.31
Average	1.0086	2.31	1.64	1.40	0.20	0.62	0.56
IV. Sugar cane:							
A. Straight—							
1. Batangas Province, Batangas	1.0164	1.10	5.96	5.60	0.36	0.34	0.21
2. Batangas Province, Batangas	1.0067	6.86	5.27	5.27	....	0.35	0.20
3. Ilocos Sur Province, Magsingal	1.0047	6.34	7.48	7.36	0.12	1.71	0.66
4. Mountain Province, Baguio	1.0200	3.97	3.96	3.88	0.08	0.34	0.12
5. Do	1.0200	4.07	3.77	3.25	0.52	0.35	0.15
6. Do	1.0100	2.79	1.15	1.09	0.06	0.36	0.24
7. Tarlac Province, Victoria	1.0275	2.89	5.79	5.57	0.22	0.75	0.56
8. Zambales Province, San Narciso	1.0265	1.29	2.90	2.63	0.27	0.67	0.25
Average	1.0165	3.66	4.54	4.33	0.21	0.61	0.30
B. Basi—							
1. Tarlac Province, Victoria	1.0191	1.63	17.74	13.86	3.88	0.61	0.43
2. Zambales Province, San Narciso	1.0912	3.70	21.36	20.97	0.39	1.19	0.21
Average	1.0552	2.67	19.55	17.42	2.13	0.90	0.32
V. Artificial	1.0062	4.55	0.46	0.46	....	0.03	0.03
VI. Cider, Commercial	1.0112	5.05	1.32	1.32	....	0.23	0.17

TABLE 1.—*The chemical composition of some Philippine vinegars*—Continued

	Alkalinity of soluble ash	P_2O_5 in soluble ash	Reducing sugars	Reducing sugars in total solids	Ash in total solids	Soluble ash in total ash
	cc o.in per 100 cc.	*mg per 100 cc.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
I. Cabo negro toddy:						
1. Batangas Province, Tanauan	27.75	26	0.05	2.89	29.47	81.31
II. Coconut toddy:						
1. Laguna Province, Bay	14.35	30	1.20	23.90	9.16	86.96
2. Tayabas Province, Lucena	16.48	15	trace		22.91	86.54
Average	15.42	23	0.60		16.04	86.75
III. Nipa vinegar:						
1. Bataan Province, Balanga	21.04	26	0.02	0.66	42.73	92.78
2. Batangas Province, Tanauan	20.67	12	trace		43.16	81.71
3. Bulacan Province, Malolos	17.07	15	trace		29.63	88.89
4. Cavite Province, Tanza	28.91	23	0.02	0.66	28.24	95.29
5. Laguna Province, Los Baños, coconut grove A	8.36	2	trace		43.64	91.67
6. Laguna Province, Los Baños, coconut grove B	15.81	8	trace		47.25	88.37
7. Laguna Province, Los Baños, Tong Store	11.80	12	0.09		37.50	94.44
8. Manila, Sibacong	26.63	17	0.07		39.38	96.05
9. Tarlac Province, Victoria	11.40	10	trace		49.37	79.49
Average	17.97	14	0.02		37.80	90.32
IV. Sugar cane:						
A. Straight—						
1. Batangas Province, Batangas	10.59	26	0.30	5.03	5.70	61.76
2. Batangas Province, Batangas	11.16	20	0.65	12.33	6.64	57.14
3. Ilocos Sur Province, Magsingal	73.52	trace	3.57	47.73	22.86	38.60
4. Mountain Province, Baguio	7.98	5	1.24	31.31	8.58	35.29
5. Do	10.59	10	1.06	28.12	9.28	42.85
6. Do	23.02	19	0.52	4.52	31.30	66.66
7. Tarlac Province, Victoria	50.68	64	0.57	9.84	12.95	74.67
8. Zambales Province, San Narciso	23.33	3	0.82	28.28	23.10	37.31
Average	27.12	22	1.09	24.00	13.43	49.18
B. Basi—						
1. Tarlac Province, Victoria	37.71	27	10.44	58.85	3.44	70.49
2. Zambales Province, San Narciso	24.90	trace	14.26	66.76	5.57	17.65
Average	31.35	14	12.35	62.81	4.60	35.56
V. Artificial	1.42	trace	0.09	0.19	0.65	100.00
VI. Cider, Heinz	18.80	8	0.27	20.45	17.42	73.91

RESULTS

The results of the analysis of twenty-five samples are given in Table 1. The first ten columns represent constituents actually determined; the last three columns are values computed from the preceding data and are given to show a certain relationship among the constituents.

DISCUSSION OF RESULTS

The results of the analysis of twenty-four locally prepared natural vinegars showed a general deficiency in acidity. The average value was 2.90 per cent, which was distinctly low when compared with the general requirement of the Federal Pure Food Law of 4 per cent. A few samples had very high acidity, notably the sugar-cane vinegars samples 2 and 3, which contained 6.86 per cent and 6.34 per cent acetic acid, respectively. Only four of the twenty-four samples could have passed the Federal standard for acidity. One sample was as low as 0.87 per cent. The palm vinegars are in general deficient in acidity, though since palm sap contains a high percentage of sugar it would be expected to yield vinegar of much higher acidity.

The total-solids content shows a wide range of percentages. Again, the cane-juice samples show higher percentages than do the palm vinegars. Those prepared from basi are markedly high in total solids; there are only two samples of basi analyzed, but they were both heavily charged with dissolved substances.

All these samples were analyzed without being filtered, and since nearly all of them were turbid or had a layer of sediment at the bottom of the container, it was thought best to attempt a quantitative measurement of the suspended matter by filtration and to determine the quantity filtered out. This was found to range from 3.88 per cent to mere traces.

The results of the determinations of total ash did not show any general trend except that sample 3 of straight cane-juice vinegar and sample 2 of basi vinegar had an unusually high total ash. These two samples did not contain phosphorus pentoxide (P_2O_5) as shown in column 9. The ash of both samples contained calcium. It is suspected that both came from limed cane juice. The lime precipitated all phosphorus as calcium phosphate. To the excess lime remaining in solution may be attributed the high percentage of total ash.

Column 9 shows the number of milligrams of phosphorus pentoxide in the soluble ash. As previously said, there were

two samples devoid of this constituent. Artificially prepared vinegar, too, has no phosphorus at all. Sample 5 among the nipa vinegars had a very low phosphorus pentoxide content. At the same time the percentages of acetic acid and total solids were also below the general trend. This may be taken as indicative of watering of the vinegar. If the constituents of this sample were multiplied by 3, the results would be in agreement with those of other samples. A large amount of water may, therefore, have been added.

It is significant that the vinegars coming from palms (column 10) have very little sugar remaining in them, while those prepared from cane juice, basi samples especially, have plenty. Such vinegars are sweet. A high percentage of sugar is an indication of improper fermentation. As stated before, there are two stages in the preparation of vinegar: the formation of alcohol from sugar and the subsequent acetification of the alcohol. The first stage should go to completion before the acetification is allowed to proceed, as otherwise, the formation of alcohol from sugar is inhibited. When this happens, the resulting vinegar is sweet and of low acidity. This is what took place in the course of fermentation of the basi vinegars.

In order to establish the interrelationships among the constituents the following were completed: the percentage of sugar in total solids, the percentage of ash in total solids, and the percentage of soluble ash in total ash.

The percentage of sugar in total solids gives a measure of the completeness of the alcoholic fermentation. It is to be seen in column 11 that the palm vinegars are generally completely fermented, for the sugar present in the total solids is very small. The opposite is true of the cane-juice vinegars; the basi vinegars contain on the average 62.81 per cent of their solids as sugars.

The per cent of ash in total solids (column 12) is expected to be constant for a given source of vinegar. This is easily seen to be the case, even if water has been added. A marked constancy is shown by the nipa vinegars. Even sample 5, which is rather below the trend in acetic acid, ash, alkalinity of ash, and phosphorus pentoxide, still shows this constancy. The average value for the nipa vinegars is 37.80 per cent. The coconut vinegars are not so constant and the average value is lower, being 19.15 per cent, or about half that of nipa. The cane-juice vinegars do not show any general trend, but as a rule give lower values than those for nipa.

The percentage of soluble ash in total ash should be still more constant in quantity than the per cent ash in total solids. That this is so, may be recognized from the following consideration: Sugar and starch leave no ash when incinerated. If added to vinegar or to the source of the vinegar, they would increase the total solids without altering the total ash. Therefore, the percentage of ash in total solids (column 12) would change in value; but the percentage of soluble ash in the total ash would still remain unchanged. It is then expected that this last percentage may be used to identify a particular vinegar, despite the addition of sugar, alcohol, acetic acid, or starch to increase the acidity. That this supposition is at least partially justified is shown by column 13. There is only one sample of nipa vinegar (No. 9) that has the percentage of soluble ash in total ash below 80 per cent. All the others have high values with an average of 90.32 per cent. Not one of the cane-juice or basi vinegars approaches such a high percentage. The other palm vinegars, coconut and cabo negro, are also characterized by a high percentage of soluble ash in total ash. In general, the greater part of the ash of palm vinegars is soluble in water.

Table 2 presents the averages of the different kinds of vinegars analyzed compared with the Federal standards. It shows that on the average Philippine vinegars are low in acidity, but meet the standard fairly well.

TABLE 2.—*Analysis of coconut sap vinegar*[a]

Sample	Specific gravity	Acetic acid	Total solids	Ash	Reducing sugar	Alcohol
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Laguna Province, Nagcarlang	1.0100	1.51	2.06	0.45	....	7.37
Leyte Province, Maripipi	1.0132	3.41	3.57	0.55	0.67	4.50
Do	1.0432	3.31	3.56	0.56	0.68	4.50
Do	1.0400	3.00	1.62	0.53	0.63	5.25
Do	1.0400	3.00	1.45	0.57	0.83	5.25
Average	1.0235	2.85	2.45	0.53	0.70	4.57

[a] From Gibbs, Philip. Journ. Sci. 6: 147–206.

Table 3 gives the variation in composition of native and cider vinegars. The range in percentage of sugar in total solids in nipa samples is low, being from 0 to 9.37 per cent; for coconut it is from 0 to 23.9 per cent. Cider, basi, and sugar-cane vinegars always contain some sugar. Basi also has a very low value for ash in total solids, being lower than any other natural vinegar analyzed. This is due to the high percentage of sugars, which

increases the solids content without altering the quantity of ash. Nipa is notably high in the percentage of ash in total solids; the minimum, which is 28.24 per cent, is almost the maximum for coconut and sugar cane, while that for basi is very far below.

TABLE 3.—*Analysis of nipa vinegar* [a]

Sample No.	Acetic acid	Total solids	Total ash	Phosphorus pentoxide	Alcohol
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
68758	2.17	1.35	0.66	....	....
68759	3.23	2.03	0.72	0.03	1.20
68760	3.03	1.54	0.72	....	3.03
Average	2.81	1.64	0.70	0.03	2.12

[a] From Gibbs, Philip. Journ. Sci. 6: (1911) 99–145.

The variation in the percentages of soluble ash in total ash for nipa vinegars is from 79.49 to 96.05 per cent. Table 3 shows that these figures have never been attained by sugar-cane or basi vinegars. It should be pointed out also that all the samples of palm vinegars have values for the percentage of soluble ash in total ash that are higher than any other native vinegar, with the exception of a lone sample of sugar-cane vinegar, No. 7.

In general then, it is found that native vinegars have peculiarities of their own and require a different set of standards of purity than those already established. The history of the samples analyzed not being known with certainty, and the number of samples being insufficient, no well defined table of standards can be drawn. Table 3, which gives the variation in composition of native vinegars, may however, be used as a tentative one. It should be noted that the acidity of native vinegars is very much below standard compared with foreign standards. The American 4-per-cent acetic acid requirement being too high a lower percentage should be used as the standard for the local products. The raw materials of native vinegars, however, are so rich in sugars, as shown in Table 4, that a much higher percentage of acetic acid could be obtained with proper fermentation methods.

SUMMARY AND CONCLUSIONS

1. Twenty-five samples of native vinegars were analyzed to study their characteristics. Of these, one sample was from

kaong; four from coconut; nine from nipa; eight from sugar-cane; two from basi; and one artificially prepared.

2. It was found that local vinegars have characteristics of their own. They have low acetic acid content with an average of 2.9 per cent; the palm vinegars generally have a very low sugar content while cane-juice vinegars are very high in sugars.

3. The palm vinegars, the nipa samples especially, have a very high percentage of soluble ash in the total ash; this peculiarity may help identify nipa vinegars despite the addition of sugar, starch, acetic acid, or alcohol.

4. The palm toddies or sap are high in sugars and with proper fermentation methods a much higher percentage of acetic acid than those found by the analysis could be obtained.

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ERRATA

Page 73, the title should read: "The Effect . . . Yield" instead of "The Effect . . . Field:"

Tables 2, 3 and 4 on page 77, change all "+" signs to "±" signs.

Page 76, line 12, "different" should read "difference."

Page 77, table 3, first column, last figure should read "35.7±1.33" instead of "45.7+1.33."

Page 78, paragraph 4 should read: "Figure 2 presents in a graphic way . . . ."

Page 80, last line, "3.6+2.29" should read "9.6±2.39."

Pages 80 and 81 under "Effect of Mulch on Yield," change all "+" signs to "±" signs.

Page 80, under "Effect of Mulch on Yield," line 6, change "+" signs between 1.17 and 21.2 to a ","

Page 82, paragraph 3, "fruits rots" should read "fruit rots."

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THE BLACK SMUT, OR BUNT, OF RICE (ORYZA SATIVA LINNÆUS) IN THE PHILIPPINES [1]

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SEVEN PLATES

INTRODUCTION AND HISTORICAL REVIEW

The first authentic report on the occurrence of black smut, or bunt, of rice caused by *Tilletia horrida* was by Takahashi in Japan, in 1896.(21) It is believed to be indigenous to that country and was inadvertently introduced into South Carolina, United States, through the importation of seed rice from Japan by the Clyde Steamship Company of Georgetown in 1896.(2) In Jure, 1899, Anderson([illegible]) reported a new *Tilletia* parasitic on *Oryza sativa* Linn., discovered in South Carolina in 1898, which was named with F. S. Earle's assistance *Tilletia corona* Scribn. [now *Till*[illegible]*data* (Arth.) Ell. and Ev.].(2, 18) This identification caused some confusion, and Earle(9) and, later, Ander-

[1] Read before the Second Philippine Science Convention, Manila, P. I., February 16, 1933. The work was conducted while the writer was still connected with the Bureau of Science, Manila. Submitted for publication August 16, 1933.

[2] Grateful acknowledgment is here made to Acting Superintendent B. R. Bautista, for offering me the hospitality of the Alabang Rice Experiment Station, Bureau of Plant Industry, and for the privilege granted to make occasional inspection of the station rice fields. Thanks are also due to Dr. C. Gaza, of the Bureau of Science, for the oral translation of the paper of P. Filter, and Dr. F. M. Clara, pathologist in charge, Plant Pathology Laboratory, Bureau of Plant Industry, for reading this manuscript.

son(2) called attention to this mistake and amended the previous report by stating that the rice smut in South Carolina was not due to *Tilletia corona* but to *T. horrida* Tak. In 1903, under the binomial *Tilletia horrida,* rice bunt was reported from Louisiana where it is believed to have occurred also on wild grasses.(23) This was probably a result of the confusion brought about by the first paper of Anderson(1) that also confused Filter(10) and others who state that *Tilletia horrida* Tak. and *T. corona* Scribn. are identical, and that *T. rotundata* (Arth.) Ell. and Ev. occurs on rice.(2) A treatise on rice diseases in Louisiana by Fulton(11) makes no mention of its occurrence on wild grasses; therefore, the report of Winkler(23) here cited cannot be confirmed. Moreover, Butler(5) states that it is not found on other hosts.

How early the disease was transported into the Philippines is not definitely known. The writer,[3] however, while making a survey of general plant diseases in various parts of the Islands, observed it first at the Alabang Rice Experiment Station in November, 1920, on standing rice of a Formosan variety called "Ryuchu" which, according to information obtained from the former Bureau of Agriculture, had recently been imported, presumably for seed purposes. This being the case, the parasite may be considered introduced. The affected panicles exhibited typical, conspicuous, external and internal black-smut features. No report of its appearance in the Philippines was made at the time as the writer then left the Government service. Later, along about the third quarter of 1930, after a lapse of almost a decade, the same disease was observed again in the same locality, now on native varieties, affecting by actual count 4 to 6 per cent in a panicle. More grains showed the presence of spores of the causal fungus adhering to them which had escaped through the fissures of the glumes or by contact with affected grains. The occurrence of a large number of diseased plants in 1930 provided sufficient material for observation and afforded an opportunity for more detailed study. While the disease at present may not be considered of great importance, under favorable circumstances it may become much more virulent. Just how serious it will be in its comparatively new territory remains to be seen. It may be safely stated, however, that it is likely to increase in severity through the promiscuous planting of seeds taken from diseased heads. We should also realize that any disease, to however slight a degree it may prevail in its territory, becomes more or

[3] Employed by the former Bureau of Agriculture.

less established on the spot, lying in wait for opportunities to give trouble to the succeeding crop. It is not safe to assume that a parasite which is of little or no economic importance in one country may not prove a destructive parasite when transported into another country.

In 1926, Bureau of Agriculture Circular No. 183, entitled Rice Diseases and Their Control, by N. G. Teodoro and J. R. Bogayong, was published.[4] This, however, was largely a compilation, which adduced no evidence that this disease at least had been seen or had actually appeared in the Philippines. The senior author himself said that he had not seen specimens of the black smut of rice before when photographs were furnished him by the writer. When fresh specimens and photographs of rice bunt were given to Dr. G. O. Ocfemia, professor of plant pathology, College of Agriculture, Los Baños, P. I., he also informed the writer that he had not actually seen the bunt of rice before. In fact, apparently no record has heretofore appeared in Philippine literature, indexes of fungi, or in herbaria, of the disease having been reliably seen or collected by others in or previously reported from the Philippines. Specimens of this parasitic fungus have now, however, been entered in the mycological collection of the Bureau of Science for the convenience of those who may wish to refer to it in the future.

DISTRIBUTION AND IMPORTANCE

As the rice bunt easily escapes detection in the field, its actual distribution may not be possible to determine definitely. Outside of Rizal Province, the distribution of black smut in the Philippines is not known, as no systematic reconnoissance has been undertaken. In the United States, it was found in South Carolina in 1899,(1) in Louisiana in 1903,(23) in Arkansas in 1926,(14) but it is not believed to have ever appeared in California.(15) This disease is widespread in eastern and southern Asia, including Malaya, and is known definitely in Japan, India, Java, Siam, and China.(4, 5) There is also a report that rice bran imported into Germany from Siam and Burma was constantly being found contaminated with rice bunt spores,(4, 5, 10) which must have been present in appreciable quantities to render them noticeable. Spores of the fungus were also detected in rice flour in South Carolina.(1) Butler(4) was inclined to think that

[4] Issued in pamphlet form and published also in Philip. Agr. Rev. **19** (1926) 237–241.

the "species is more widely distributed in South-Eastern Asia than appears from the scanty records." Rhind(17) in 1925 reported that the disease was more prevalent in India than usual. Duport(8) and Vincens(22) reported having observed it in French Indo-China. This rice disease occurs also in British Guiana, according to Stevenson.(20)

In Japan, Takahashi(21) reported that this disease affects only a few grains in the panicle, and according to Miyake(16) it is not prevalent. In the United States, however, where it was casually introduced, it assumed destructive proportions, causing as much as 25 per cent damage to smutty crops in South Carolina.(11) Cook(6) considers it as probably the most serious of the diseases of rice of lesser importance. Its apperance in some countries is more or less sporadic, and the damage occasioned by this ubiquitous rice parasite in eastern and southern Asiatic rice-growing countries is generally slight; but certainly it is more destructive than the rice false smut or green smut, or other diseases known, which likewise operate on the grain. Grains attacked are good neither for seed nor for human consumption. It may lower the market value as smutty rice does not command as good a price as clean rice; and the color of the flour when smut is present to an appreciable extent may be spoiled and similar damage caused. In other words the disease reduces not only the quantity but also the quality, and though a small proportion of black smut is admissible and does not seriously reduce the yield or the quality of grain, yet even a small percentage of the smut is objectionable.

Reduction in yield is also due in part to the morphological reactions of the plants to the disease, such as stunting, failure to head, and distortion and partial sterility of the infected heads.

SYMPTOMS AND EFFECTS

Not until the grains begin to ripen does the blackening due to smut become discernible at close range; and it would seem much more difficult to detect if it happened to attack varieties having fixed pigment on the hull during maturity. Diseased panicles are carried by the culms in the same manner as the uninfected ones, and usually not all culms in the same stool bear diseased heads. The disease is recognized generally by the presence on the surface of the grains of a black, powdery or sooty mass of spores (Plate I) sticking together and usually clustered towards the tips of the unaffected hull or on their hairy portions (Plates II and III). Under ordinary conditions the heads are only

partially smutted. Some grains are covered almost entirely by the black mass of spores. Others show very little signs of the disease, while a great number are hardly distinguishable from normal grains, and thus it is that even expert observers can be deceived sometimes. This disease is more clearly differentiated if seen through a magnifier, but macroscopically it may be confused with *Helminthosporium* or other grain-inhabiting organisms of rice by anyone who is not well acquainted with these diseases.

Ordinarily the affected panicles show only a few blackened grains in one or two spikelets, but in fairly severe cases of infection more spikelets show blackened grains, but bear no fixed position in the head. Sometimes the infected grains gape or show a little separation of the tips (Plate III, *d*) as a result of the slight enlargement of some of the kernels, and occasionally also a short, somewhat beak-shaped or inverted, spurlike outgrowth (Plates II and III), capable of resisting weathering, comes out by rupturing any portion of the keel of the larger glume or lemma in severe infection, thus increasing the visibility of the fungus. This protruding spurlike structure is nothing but the shrunken or atrophied remnant of the eaten-out endosperm, which remains intact, extruded through the inclosing membrane and the inner glume by force through the multiplication of the spores inside. A careful examination with a hand lens will reveal that the remaining endosperm is practically covered with spores, and the shallow superficial cavities formed by the fungus are clearly noticeable. This is rather an extraordinary but striking indication of this grain-infesting smut and is believed to have been observed for the first time. These structures stretch out generally at an angle downward (Plate II), but occasionally upward or horizontally and are usually covered with spores, thus facilitating the latter's distribution. They are usually grayish black, but rarely pink, or purplish pink, and resemble somewhat the peculiar appearance of ergot. These characteristic features taken together are the outward symptoms of the disease.

Internally, on cautiously opening the bunted grains, one will see that the kernel is covered with a more or less transparent or gray membrane (cuticle), with the fungus transforming the ovary partly or wholly into a dense, stooty-black mass of spores (Plate III, figs. *b*, *c*, *e*, *f*). When this occurs in a wholesale manner, the host plant is unable to reproduce itself. This is the most distinguishing feature of the rice bunt. In the ad-

vanced stage the kernel is replaced entirely by spores (Plate III, *f*) and this is what causes the actual loss. But the heads destroyed by the fungus cannot be regarded as an absolute index of the total damage, because beyond the evident indications the presence of the fungus in the system causing a disturbance in the normal functions of the plant affects the growth and decreases the yield, as demonstrated by pot and field experiments.

ETIOLOGY

DESCRIPTION AND IDENTIFICATION OF THE FUNGUS

According to a system of classification, the parasite causing the black smut, or bunt, of rice belongs to a subgroup of the Basidiomycetes, subclass Hemibasidii. It is a species of the order Utilaginales and is included in the most important genus of the family Tilletiaceæ. It falls in the group of fungi the members of which often cause serious damage to cereals, and are considered as being among the most destructive of plant diseases. The causative fungus, *Tilletia horrida* Tak., is closely allied to the organism causing the well-known stinking smut, or bunt, of wheat, a disease of world-wide evil fame.

The gross symptoms, as determined by field observations, and microscopic examinations of the spores from infected heads indicate beyond reasonable doubt that they are typical of *T. horrida* with respect to color, shape, size, and surface features. The spores are single-celled and relatively large as compared with those of other fungi, forming a black, homogenous, pulverulent mass at maturity. The sori are found in the ovary and are enveloped in the unaffected glumes.

Spores of different stages are present, usually inside the ovary, and are variously compressed, assuming different sizes and shapes (Plate IV). The immature spores are hyaline, subhyaline, or yellowish, the latter two exhibiting blunt spines. The hyaline spores are generally smooth. Some of the young spores are shrunken and generally elongated (Plate IV, fig. 1); others are without contents or spinous wall-projections but with peripheral thickening (Plate IV, fig. 3). Sometimes a short narrow hypha (pseudo-pedicel) may be seen attached to the thickened portion of the young spore (Plate IV, fig. 2, which later disappear through gelatinization. Tiny bits of septate vegetative mycelium (Plate IV, fig. 6, *b*, *c*) have also been noticed with the spores. Subhyaline spores show clearly the arrangement of rudimentary, blunt wall-projections and their reticulose formation (Plate IV, fig. 4).

The mature spores (Plate IV, fig. 6, *a*) are opaque, olive-brown to black, globose to subglobose or occasionally elliptical; and the surface is provided with slightly colored or hyaline, spinous, scalelike projections. These echinulations, which are more conspicuous in less opaque spores (Plate IV, fig. 5), are frequently curved and pointed at the apex (Plate IV, figs. 5 and 6, *a* and Plate V, fig. 2). On mature spores they are irregularly polygonal at the base (Plate V, fig. 1) and form a band at the periphery about 2.57 to 4.28 microns in breadth.

Measurement of spores.—For purposes of comparison, spores of *Tilletia horrida* found on rice in the Philippines were obtained from infected grain in which the kernel is more or less replaced by the black powdery mass of spores, and mounted in water. On account of the slight variability in size of spores, and the disagreement in the measurements made by other workers, a sufficiently large number of measurements or a total of 200 globose spores and 200 elongated spores were measured both for length and width, to determine accurately the average size.

Compared with measurements given by other authors after deducting the breadth of the band of scales included in the writer's measurements, it will be seen that the spores of rice bunt found in the Philippines approximate closely the measurements made by workers in other countries, especially those of Takahashi, who first described the species.

TABLE 1.—*Spore measurements given by other authors.*

Takahashi.(21)

Spores globose, irregularly rounded, or broadly elliptical; rounded, 18.5 to 23.0 μ; elongated, 22.5 to 26.0 by 18.0 to 22.0 μ.

Anderson.(1)

Spores spherical to broadly elliptical, 26 to 30 μ diameter, including the hyaline envelope, 2 to 3 μ thick.

Fulton.(11)

Spores spherical to slightly oval, 22 to 28 μ.

Stevens.(19)

Spores subspherical to spherical, 22 to 33 μ long. Band of scales, 2 to 4 μ wide.

Butler.(5)

Spores round or rarely elliptical, 20 to 24 μ in diameter.

Winkler.(23)

Spores rounded, 20 to 33 μ in diameter.

As shown by the measurements of different authors given in Table 1, the spores of *Tilletia horrida* are slightly variable in size. The range of variability was found by the writer to be as follows: Globose, 23.37 to 30.21 μ by 25.65 to 31.35 μ; and

the elongated, 21.66 to 31.35 μ by 26.79 to 35.34 μ. Taking the average of the two extremes, the globose spores are 26.79 to 28.5 μ and the elongated 26.5 to 31.06 μ. These measurements include the width of the peripheral band or spinous or scalelike, hyaline projections, approaching closely the measurements of Anderson,(1) which also include the hyaline band. By subtracting from these measurements the width of the hyaline band, they also conform with those of Takahashi.(21)

In Japan, Takahashi(21) observed the germination of spores in water in three days. According to this author, the short germ-tube, or promycelium, was septated at the tip (1 to 3 septa); and 10 to 20 filiform, curved sporidia (38 to 53 μ long) were borne terminally in clusters. On separation from the promycelium, the sporidia became 3- to 4-celled. No fusion of the sporidia was observed.

With the exception of the spore germination, in which negative results were obtained in all attempts, even with the use of different concentrations of nutrient media, all the other principal distinctive morphologic features of the fungus, as admirably described by Takahashi,(21) have been confirmed by the writer. Even without ascertaining the mode of spore germination as a basis for the separation of the two smut families, the writer firmly believes that the black-smut fungus found on rice in the Philippines is identical with the disease of rice caused by *Tilletia horrida* Tak.

TRANSMISSION OF THE DISEASE FROM SEED-BORNE SPORES

POT EXPERIMENTS

Rice plants attacked by this disease do not generally exhibit marked differences from healthy ones during growth, according to previous observers. In his investigation upon the black smut of rice, Anderson (1) found evidence of the fungus hyphæ in the stem tissues of infected plants and he thought it reasonable to assume that seedling infection took place from spores adhering on the outside of the grains. In an effort to test the transmissibility of the disease or its reproduction through the planting of infected seeds, fifty plump, germinable seeds of the Sipot variety, showing a light spore-load were selected, soaked in sterile water overnight, and then sown in sterilized soil of uniform character in pots. Thus the spores were sown with the seeds. Another fifty seeds selected from healthy panicles were treated similarly and sown in another sterilized pot of soil from the same source, on June 15, 1931. The pots were subjected to controlled

conditions in a glass-roofed greenhouse which gets sunlight and usually registers a higher air temperature than the open. Of the fifty smutted seeds sown, only thirty-six germinated, while fourteen of them failed to germinate, although two showed initial signs of growth. All the healthy seeds germinated and grew normally. Twenty-nine of the surviving young bunt-seedlings exhibited a sort of etiolated or pale yellowish condition of the older leaves (Plate VI, fig. 1) in the early stages of growth, while seven seedlings showed similar symptoms on the younger leaves. Severe stunting was also exhibited in diseased seedlings, while none of these symptoms appeared in the controls (Plate VI, fig. 2). This phenomenon is generally termed "grain (seedling) infection," or infection from seed-borne spores. The infection is brought about by the simultaneous germination of seeds and spores, the latter producing short basidia (3) (promycelia), which form clusters of elongated terminal basidiospores (sporidia), which in turn produce infection hyphæ that penetrate the soft and tender tissues of the newly sprouted seeds and grow with the host until the spores break out again. The effect of the disease on the growth of thirty-six seedlings in each pot are given in the measurements of single plants in Table 2. In comparison with seedlings produced from healthy seeds, the foliage showed no chlorotic condition; they were healthy and green in spite of the crowded condition of the plants.

TABLE 2.—*Comparing the growth of healthy and smutted rice seedlings*

	Height of seedlings produced from smutted seeds (centimeters)			Height of seedlings produced from sound seeds (centimeters)[a]		
	42.6	42.2	44.6	65.0	64.0	59.0
	43.0	40.0	43.3	63.7	55.8	62.3
	41.5	45.7	46.0	57.0	56.6	61.0
	51.0	43.8	41.8	66.0	55.5	67.1
	47.6	43.0	43.5	61.2	66.5	64.2
	45.0	46.1	36.0	60.0	59.5	60.0
	44.0	45.4	35.4	58.7	64.2	54.0
	43.0	42.2	38.2	59.6	57.5	55.7
	46.4	45.0	37.3	56.5	64.3	58.0
	45.0	41.0	38.5	54.8	60.0	56.0
	45.5	40.9	42.5	54.5	61.0	60.5
	41.8	47.0	38.0	61.0	55.3	62.0
Total	536.4	522.3	485.1	718.0	720.2	719.8
Grand total			1,543.8			2,158.0
Average height			42.88 ± 0.3810			59.94 ± 0.4114
Probable error of difference						17.06 ± 0.5607

[a] Measurements were taken at random.

It will be seen from the preceding data that there was a significant reduction in height in the seedlings grown from slightly smutted seeds, due to disturbances caused by the fungus in the normal physiological processes. In spite of the crowded condi-

tion of seedlings grown from healthy seeds, they were much taller (Plate VI, fig. 2) the average height being 59.94 ± 0.4114 centimeters and that of the diseased seedlings (Plate VI, fig. 1) 42.88 ± 0.3810 centimeters, showing a significant difference of 17.06 ± 0.5607 centimeters. Due to reflected light from the glass roof of the greenhouse at the time of exposure, some of the leaves of the control seedlings (Plate VI, fig. 2) appear as to show signs of discoloration also.

Fifteen of the severally diseased seedlings were transplanted in the open in three large concrete pots containing the same quantity of sterilized, uniform soil and five healthy seedlings were transplanted in similar soil in another pot and used as a check. At maturity, October 3, 1931, the plants were photographed (Plate VII), and measurements of the height of all the plants were taken, the number of bearing culms produced were counted, and the grain yield was weighed, as shown in Table 3.

TABLE 3.—*A comparison of the general vigor and yield of plants grown from smutted and healthy seedlings*

[S, with smutted heads; O, no smutted heads; D, dead.]

Pot	Plant 1				Plant 2			
	Culms	Average height of tillers	Result	Grain yield	Culms	Average height of tillers	Result	Grain yield
		cm		*g*		*cm*		*g*
I	5	120.5	S	9.75	7	121.5	S	14.38
II	9	120.2	O	20.45	7	123.6	S	16.56
III	7	92.9	O	7.44	5	81.4	S	6.49
Check	12	137.8	O	27.30	8	136.6	O	26.97

Pot	Plant 3				Plant 4			
	Culms	Average height of tillers	Result	Grain yield	Culms	Average height of tillers	Result	Grain yield
		cm		*g*		*cm*		*g*
I	6	123.3	O	9.00	3	183.3	O	5.05
II	6	123.7	S	14.13	7	121.8	S	12.23
III	7	85.4	S	9.29	6	79.7	S	10.05
Check	9	143.0	O	19.35	12	134.1	O	30.85

Pot	Plant 5				Average number of culms per plant	Average height of plants	Average grain yield per plan
	Culms	Average height of tillers	Result	Grain yield			
		cm		*g*		*cm*	*g*
I	6	125.4	S	13.96	5.4	134.8	10.43
II	D	0.0	D	0.00	7.2	122.3	15.84
III	5	86.3	S	5.78	6.0	85.1	7.81
Average per pot	......	......	......	......	6.2	114.0	11.36
Check	12	142.0	O	21.31	10.6	138.7	25.15

Of the fifteen seedlings transplanted in relatively big pots, one perished due to the disease. A very interesting result of the experiment is that not all the diseased seedlings transplanted in the open developed smutty heads. Some of the heads apparently showed no trace of bunt infection, which may partly be accounted for by the presence of conditions unfavorable for fungus development during the early growth of the plants, so that the vegetative mycelium failed to ramify to all parts of the plant, the fungus filaments at the base reaching only the growing point of slow-growing plants. The receptivity of the individual plants in this case differs towards the smut fungus and even in the same material under similar conditions only a portion of the host plants became smutty. The number of spores present influences the resulting infection, as those situated on the embryo or its neighborhood have greater chances to cause infection than those more remote. This does not mean, however, that the diseased seedlings on maturity no longer harbor the parasite, but that the vegetative organs were feebly present and failed to reach the panicles before the maturity of the grains. But that infection is one of true systemic development, pervading the plant tissues, cannot be doubted. The control plants remained healthy.

An examination of Table 3 will reveal that the stunting effect of the disease on the growth of the plants was very evident at maturity; the diseased plants and the control plants being on the average 114.0 centimeters and 138.7 centimeters in height, respectively (Plate VII). Fewer tillers or bearing culms were produced in the diseased plants than in the healthy plants, or in round numbers, 6 against 10, respectively, per pot. With regard to grain yield, a considerable diminution was observed in the smutted plants; for while the diseased plants yield on the average 11.36 grams per plant, the healthy, control plants yielded 25.15 grams per plant, or 54.83 per cent more. Although these experiments were not as extensive as they should have been, they show that the disease undoubtedly produces stunting and a subsequent decrement in grain yield and in straw coincident with the production of typical black smut symptoms. Thus we may say that the experiments began with diseased seeds and ended in diseased seeds.

FIELD EXPERIMENTS

July 10, 1931, twenty-one of the diseased Sipot seedlings showing a milder degree of stunting and chlorotic effect than those

used in the pot experiment, and twenty-one of the healthy seedlings also sown in the greenhouse were transplanted singly, 20 centimeters apart in the row, in a lowland rice field where no smutty rice crop was grown. The check plants were transplanted some distance away, but they were given precisely the same treatment. In other words the plants were afforded ample room for development. At maturity the height of the plants was measured, and later the panicles of each plant were gathered and placed in separate paper bags. The results of this test are given in Table 4.

A study of Table 4 brings out the fact that sixteen of the plants grown from infected seedlings produced smutted plants and five plants were apparently normal. The computations given, however, were based on the number of smutted heads. On this basis a lower percentage of infection, or 1.39 per cent, resulted than would have occurred had the whole plant been used as a basis. Usually only one or two heads on the plant, and quite often only a few grains on the head, showed infection. A better appreciation, however, of the toll taken by the disease could be obtained by making a critical scrutiny of the stunting effect and grain yield. The smutted plants had an average height of 165.8 ± 1.0632 centimeters showing considerable stunting by a difference of 10.1 ± 2.8763 centimeters in the average height from that of the healthy plants which was 175.9 ± 2.6723 centimeters.

The panicles of each plant were threshed separately and weights were taken of the yield. The smutty plants gave an average of 72.6 ± 3.6950 grams and the normal plants 84.0 ± 4.8292 grams, showing a difference of 11.4 ± 6.0806 grams, or 12.8 per cent. As regards the grain yield in this case, the seedlings transplanted, to begin with, showed only mild symptoms of the black smut, with no severe effects, so that there was only a slight increase in favor of the normal plants over the diseased plants, or an average of 11.4 grams per plant. Five of the plants in the supposedly diseased plat were observed to be smut-free, as far as panicle examinations were concerned, which may be accounted for, presumably, by the favorable conditions obtaining for the host plant to outgrow or resist the progress of the fungus. The results seem to strengthen the previous observations that the season of planting appears to influence to a large measure the outbreak of the disease. As has been observed, dry-season planting seems to predispose the rice plants to this disease more than the wet-season planting does.

TABLE 4.—*Rice plants produced from smutty seedlings compared with those produced from disease-free seedlings*

Grown from smutty seedlings					Grown from smut-free seedlings				
Plant No.	Height at maturity	Heads	Smutty heads	Grain yield	Plant No.	Height at maturity	Heads	Infested heads	Grain yield
	cm			*g*		*cm*			*g*
1	171	30	4	119.7	1	210	45	0	184.7
2	162	22	5	110.0	2	171	20	0	97.6
3	146	14	2	35.9	3	163	17	0	70.7
4	163	16	2	82.4	4	166	19	0	74.9
5	168	20	3	63.7	5	196	23	0	103.9
6	172	25	3	88.6	6	202	21	0	113.3
7	175	17	2	48.0	7	203	21	0	63.2
8	178	21	4	84.9	8	163	13	0	53.2
9	162	20	5	102.9	9	192	15	0	59.2
10	169	14	1	42.9	10	203	14	0	57.3
11	176	24	0	99.8	11	161	26	0	81.5
12	168	13	2	47.6	12	166	21	0	83.2
13	158	14	2	83.6	13	167	33	0	115.6
14	157	20	3	65.2	14	165	22	0	81.8
15	163	24	2	98.1	15	155	44	0	163.9
16	159	11	0	32.6	16	200	26	0	87.0
17	166	24	0	80.3	17	167	21	0	79.9
18	170	25	0	81.0	18	160	23	0	80.0
19	171	24	1	81.2	19	161	20	0	76.2
20	165	29	4	69.0	20	160	16	0	71.2
21	163	26	0	108.4	21	164	15	0	66.9
Total	3,482	433	45	1,625.8	Total	3,695	475	0	1,865.2
Average	165.8	20.61	[a] 1.39	72.6	Average	175.9	22.61	0	84.0
Probable error of mean	±1.0632			±3.6950		±2.6723			±4.8292
Probable error of difference						10.1±2.8763			11.4±6.0806

[a] Per cent infection.

July 10, 1931, one hundred Sipot seeds slightly coated with bunt spores, soaked previously in clean water, were sown in a rice seedbed at Alabang, Rizal Province. Another batch of one hundred seeds from bunt-free stock of the same year's crop was treated in the same way and sown in another seedbed. Transplanting of the seedlings was done August 24, 1931, singly in rows side by side, 20 centimeters apart, and spaced 20 centimeters in the row. At the time of maturity the heights of the plants in both plats were measured and later, when harvest time came, the number of panicles per plant were counted. The weight of the grains of each plant was taken. The data obtained from this experiment are shown in Table 5.

Here it is noted that although all the seeds sown bore spores on the outside, some of those which were able to germinate but were more resistant to the disease succumbed, while those which were more resistant survived. The number of seedlings produced was counted in each lot, and it was found that only 64 grew from the smut-spore-covered seeds while 94 seedlings developed from the healthy seeds. Despite the fact that all the seeds were sown in the same soil and transplanted alongside each other in similar soil, the plants were not equally infected and a number escaped infection, the vulnerable period being only of short duration. This suggests also the possibility that the infection thread had penetrated into the seedlings but failed to reach the growing point, which may also be accounted for by the variation in time of germination of the individual seeds.

Summarizing the data given in Table 5, another tabulation is here presented designated as Table 6, which shows quite significant figures obtained from the result of this experiment as regards the heights of plants, but not so with the grain yield.

It will be seen in Table 5 that only a few of the plants produced from smutted seeds showed considerable stunting. In order, however, to be able to make a fair comparative study of the result of the test only an equal number of plants in the healthy plat were observed, and it was found (Table 6) that the diseased plants had a mean height of 141.80 ± 1.1382 centimeters and the healthy plants 149.92 ± 0.8511, centimeters or a difference of 8.12 ± 1.4212 centimeters.

On examining the panicles from the diseased plant (Table 5) only 28 panicles, or 5.98 per cent were found smutty. In every case there was a mixture of smutted and disease-free panicles in the same plant. Even infected plants were only partially bunted and there was a greater proportion of sound than of

TABLE 5.—*A comparison of the growth, number of panicles, and grain yield of rice plants grown from smutty and normal seed*

Grown from smutty seeds								Grown from normal seeds							
Height of plant	Panicles	Panicles infected	Grain yield	Height of plant	Panicles	Panicles infected	Grain yield	Height of plant	Panicles	Panicles infected	Grain yield	Height of plant	Panicles	Panicles infected	Grain yield
cm			*g*	*cm*			*g*	*cm*			*g*	*cm*			*g*
138	12	1	30.0	151	6	1	20.5	164	19	0	52.0	154	5	0	16.0
147	16	0	40.5	145	6	0	17.0	140	12	0	35.5	144	7	0	15.0
149	7	1	22.5	148	5	0	20.0	143	14	0	43.5	153	4	0	11.0
144	6	0	20.0	146	5	0	13.0	151	14	0	40.0	158	5	0	13.7
88	0	0	0.0	145	6	1	18.0	156	11	0	34.5	147	5	0	12.5
146	11	2	30.0	140	5	1	14.0	143	9	0	27.0	147	5	0	13.7
152	14	1	39.5	153	7	0	20.0	145	11	0	32.0	187	6	0	29.0
147	15	0	54.5	155	18	0	22.0	149	11	0	29.0	142	11	0	29.0
78	0	0	0.0	165	7	0	17.0	157	13	0	38.0	158	8	0	25.0
148	9	2	21.5	142	7	0	23.0	151	13	0	39.5	158	13	0	40.0
153	11	2	31.0	142	9	1	4.0	144	9	0	22.5	155	8	0	24.5
150	14	0	29.0	150	5	0	17.5	145	8	0	21.5	165	6	0	16.5
149	8	1	31.5	136	0	0	0.0	141	13	0	36.5	173	4	0	11.0
145	9	2	30.0	149	8	0	13.0	143	5	0	12.5	147	4	0	10.0
149	15	0	35.0	152	6	1	14.0	140	9	0	24.0	152	4	0	12.0
148	12	1	37.0	139	6	0	10.0	144	7	0	16.7	148	7	0	16.7
146	9	0	28.0	143	4	0	6.5	141	8	0	23.0	147	5	0	13.0
149	8	0	19.0	151	3	0	7.0	145	8	0	17.7	143	5	0	12.5
152	11	1	30.5	152	3	0	12.5	174	6	0	20.7	149	7	0	14.5
136	16	0	45.0	151	6	0	16.5	140	18	0	44.7	154	4	0	9.0
137	11	0	36.0	154	5	0	15.0	192	8	0	29.0	151	6	0	16.5
143	8	0	21.0	143	4	0	12.5	156	8	0	20.5	145	8	0	23.0
146	5	2	8.0	147	5	1	10.2	150	6	0	14.5	159	4	0	8.0
150	4	1	13.0	152	5	3	18.0	151	7	0	16.5	151	13	0	40.0
144	6	0	23.0	148	5	1	19.0	147	7	0	18.5	150	3	0	8.0
139	4	0	11.5	146	8	0	8.0	151	7	0	14.5	152	5	0	13.0
143	6	0	19.5	152	4	0	10.7	158	5	0	14.7	150	6	0	15.0
143	8	0	26.0	153	10	0	29.0	142	4	0	10.5	155	11	0	32.7
106	7	0	25.0	154	10	0	15.0	172	6	0	15.7	150	7	0	20.7
141	7	1	15.5	138	6	0	13.5	144	9	0	16.5	144	5	0	10.7
148	3	0	12.5	137	3	0	4.5	150	4	0	8.2	159	2	0	3.0
149	6	0	20.0	130	3	0	7.5	152	7	0	20.0	154	4	0	6.0

diseased stalks. In three plants the growth of culms as well as the development of heads was somewhat arrested and when maturity was reached heading was presumably much delayed, so that there are no grain yields given.

TABLE 6.—*Summary of Table 5*

Material	Plants	Mean height	Mean yield	Difference in height	Probable error of difference	Difference in yield	Probable error of difference
		cm	*g*	*cm*		*g*	
Diseased....	64	141.80±1.1382	17.73±0.9394	....	....	....	....
Control.....	64	149.92±0.8511	18.90±0.9295	8.12	±1.4212	1.17	±1.3215

In grain yield (Table 6) there was a slight difference of 1.17 ± 1.3215 grams, the diseased plants, producing an average of 17.73 ± 0.9394 grams and the healthy plants 18.90 ± 0.9295 grams. The smutted plants as a whole produced a slightly lesser number of bearing culms; and the heads were somewhat lighter than the normal heads, in some instances. The decrease in grain yield may be explained by the fact that even when the straw is fully developed, the grains may be poor because the needs of the fungus have to be provided for as well as those of the host plant.

An important fact is here brought out and made more evident, that is, that a certain degree of heat is invariably indispensable for the proper development of the organism as well as other conditions that of necessity must prevail simultaneously in order to produce successful infection. And it has been observed in the field that rice plantings at the outset of the summer months were more readily affected by the disease than those grown during the rainy season, which theory seems to have been borne out by sowings made inside a glasshouse and those made in the open where the temperature varied in the two environmental conditions. In other words the proper season of the year is essential for the germination of the spores, which seems to be stimulated also by a high temperature.

HISTOLOGICAL EVIDENCE

That the black smut of rice is systemic is unquestionable and so we would naturally expect a certain host response, such as a disturbance of its normal physiological function. Seedlings grown from slightly infected seeds producing seedlings exhibiting a kind of pallor on the leaves developed black smut in the grains on maturity. No attempt was made to make a histological study of the tissues of smutted plants, but from the conditions of the experiment there is every reason to believe that the etio-

lated and stunted condition of seedlings produced from slightly smutted grains proved that the fungus is present in such host tissues, gaining entrance during early growth. As cited by Stevens(19)[5] "cross section of stems bearing smutted heads reveal the mycelium in the chlorophyll perenchyma between the fibrous tissue." The findings of Anderson(1) convincingly show the mode of infection of the stem tissues. Eight inches (20 centimeters) below the panicles of the infected plant, the stem showed, in cross and longitudinal sections, the presence of a mycelium very similar to the diametrically larger mycelium found associated with spores in the ovary. It is claimed this is present only in the subepidermal vertical rows of loose chlorophyll parenchyma, which lie beneath the rows of stomata in the epidermis." None was found in the stereome, nor in the vascular bundles and colorless parenchyma in the inside of the culm. It seems probable that the chlorotic appearance of some seedlings seriously affected was due to this internal invasion. Sections of the rachis showed similar mycelium.

FACTORS INFLUENCING DEVELOPMENT

There are certain ecologic conditions which predispose rice to bunt and due to these conditions the degree of smutting fluctuates. According to observations, rains followed by hot sunshine immediately after sowing are conducive to its rapid development as the emerging seedlings are at once exposed to the possibility of infection. But this is also influenced by the host susceptibility and by the abundance of smut spores present in the soil or on the seed. It seems probable that excessively damp soil or impermeable soil continuously under water during the entire growing period of the plants are also contributory agencies. Field observations seem to indicate that susceptibility is more pronounced when planting is done in "palagad," or during the dry season, under irrigated conditions, than in the regular rice season, probably due to the prevalence of hot weather and the presence of abundant stagnant water or artificial irrigation. That the intensity of attack by this disease varies from year to year and even in the same variety of rice seems to confirm the writer's belief that weather or some other environmental condition has really a certain relation to the occurrence of the disease. As with members of this group of fungi it multiplies rapidly when favorable conditions obtain. In the

[5] Anderson, A. P., South Carolina Bull. 41 (1899).

studies of Appel and Riehm, as cited by Woolman and Humphrey,(24) these authors have consistently shown that tilletia grows readily enough in the soil, probably due to the presence of organic flora.

DISSEMINATION

The fungus is undoubtedly distributed in nature most extensively by spores adherent to the outside of the grains and by those produced within the grains. The disease is transmitted to the succeeding crop by planting infected grains, or grains with spores adhering to them, for when the grains germinate by reason of a certain unknown stimulus, the spores germinate also and the germ-tubes infect the rice seedlings. Slight infections are difficult to detect and by subsequent inadvertent planting the infection may be increased.

As with other cereal smut disease, soil infection seems highly probable which facilitates disease transmission from crop to crop. It may also be possible that the spores are carried by the wind from diseased heads to healthy ones, especially when varieties of rice maturing at different periods are grown.

The spread of the disease is generally brought about when sound and infected panicles are harvested and mixed together in the threshing. The danger of sound grains becoming contaminated with the millions of spores in heavily smutted grains smashed by threshing operations is great and it should be realized that each individual spore discharged and scattered is capable of reproducing the disease. The sticky bunt spores, which usually adhere to the hairy portions of the glumes of germinable seeds, may germinate when the seeds are sown and in this way the disease be carried or propagated from crop to crop. Burst grains or grains with tips forced apart, or with spurlike outgrowths due to bunt infection expose the mass of spores within and spores dissipated by the wind may lodge on the grains of healthy plants, which when planted later may cause subsequent infection. This adequately explains the source of infection in succeeding crops. The spores being very sticky adhere readily to many objects they come in contact with and are thus dispersed.

The possibility of soil infestation through the falling off of bunted grains or panicles to the soil, especially during harvest time is great. Spores blown by the wind may be scattered on the ground. The disease may also be spread by infected implements, bags or sacks, winnowing machines or by other mechanical means.

As the spores develop under the cuticle of the grain consisting of the wall of the ovary and the outer layers of the true seed, and as this outer covering is removed in milling and comprises a great part of the rice bran, it can be easily seen how smutted grains contaminate this by-product of rice as well as flour. When infected rice or bran is fed to fowls, hogs, cattle, horses and other animals, and the viability of the spores is retained or not in any way injured or decreased after passing through the digestive tracts of such animals, the spores contained in their manure are thus in danger of being scattered .

When varieties maturing at different periods are planted in the same field or in close proximity with each other, the chances of infection from an infected variety to an uninfected one by contact with aërial spores is likely to occur. Fulton,(11) Copeland,(7) and Mackie(15) think the flower-infection phenomenon a probability but they have no evidence to support it.

ARTIFICIAL INFECTION OF RICE PANICLES WITH THE BLACK-SMUT SPORES

Infection through the flower has been carefully demonstrated by experiments with other cereal smuts. With rice bunt, however, although certain authorities believe it takes place in nature, no experiment has been made, as far as the writer is aware. This experiment, therefore, was conducted in an attempt to reproduce the black smut through the use of spores by spraying them on the panicles. Normal rice panicles of the Sipot variety at different stages of development were sprayed with smut spores dispersed in water; (*a*) on emerging inflorescences, (*b*) during the blossoming period, (*c*) at the milk stage, (*d*) at the dough stage, and (*e*) on maturing panicles. The spraying treatment was the same, an atomizer being used in order to secure a fine mist that would adhere readily to the surface of the sprayed panicles at the same time making a uniform distribution of the spores, and then the sprayed panicles were immediately covered with paper bags. An equal number of plants with their panicles in the same stages of development were sprayed at the same time with blank sterile water and bagged likewise to serve as controls. Spraying was all done early in the morning, and on the supposition that the spores would germinate on the moist surface of the panicles. Following the examination, both macroscopically and microscopically, of the sprayed and unsprayed panicles, the details were carefully noted and are shown in Table 7.

TABLE 7.—*Artificial infection of normal rice panicles at different stages of development by spraying with spores in water suspension*

Stage of development of panicle	Date sprayed	Stools	Panicles	Panicles infected	Remarks
Sprayed					
1. Emergence of panicle...	Sept. 28, 1931	4	4-6-6-6	0	Trace of inoculum on hull.
2. Flower stage [a].........	Oct. 9, 1931	4	5-4-5-6	0	
3. Milk stage............	Oct. 16, 1931	4	5-5-5-5	0	Spores found on hull.
4. Dough stage...........	Oct. 23, 1931	4	5-5-5-5	0	
5. Maturing.............	Oct. 30, 1931	4	5-5-5-5	0	
Check					
1. Emergence of panicle...	Sept. 28, 1931	4	5-5-5-6	0	
2. Flower stage [a].........	Oct. 9, 1931	4	5-5-5-5	0	
3. Milk stage............	Oct. 16, 1931	4	5-5-5-5	0	
4. Dough stage...........	Oct. 23, 1931	4	5-5-5-5	0	
5. Maturing.............	Oct. 30, 1931	4	5-5-5-5	0	

[a] The flowers were yet closed when spraying was done.

As will be seen from Table 7, mature spore infection seems to show the futility of trying to reproduce the disease by spraying panicles with spores in suspension. After harvest all the panicles so treated were examined with the aid of a magnifier but none of them exhibited any sign of the disease. In a few panicles, however, as in stages 1 and 3, some dark spores typical of the black smut were detected on the glumes but these showed no indication of germination as confirmed by microscopic examinations.

How the spores can find their seedbeds when the flowers are closed and protected by the glumes is really something to wonder about. But the reason for these negative results might be explained by one or two possible factors; first, that the most favorable period was not exactly hit and, second, that the technic was not precisely the correct one to follow. Also, spores from natural host plants when transferred to pure water might have received some injury which resulted in their death or weakened development. It is believed that the infection of panicles can only occur during the receptive stage of the flower, or before the incipient formative state of the ovary, as it is possible that the germ-tube may find its way into the developing ovary. It is not known what success would be obtained if spores were sprayed on the stigma of open flowers or by putting spores on the walls of the nascent ovaries, as no test has been made to demonstrate the effects of these methods. On account of its practical importance, and as these trials are not extensive enough, flower infection under almost natural conditions should be tested by further experiments.

The panicles bagged during the early periods of panicle development, stages 1 and 2, produced a considerable percentage of chaffy grains indicating the detrimental effects on grain formation of covering the panicles with paper bags even if the bags are loosely tied at the base. For the same reason the writer entertains the belief that bagging probably causes certain injurious effects on the germination of the black smut spores.

VARIETAL SUSCEPTIBILITY

Field experience has shown that varieties seem to differ to a certain degree in their liability to the disease. The early varieties, perhaps because of the coincidence of warm, moist weather at the time of the ripening of the panicles apparently showed more susceptibility than the late varieties. "Palagad," or dry-season rice varieties like Sipot, for instance, have been observed to be easily attacked by the black smut. Guinangang Str. 1 and Apostol, two other early-maturing varieties, also showed slight susceptibility, while Mancasar Str. 3 appeared to be comparatively resistant. Elon-elon was unaffected, apparently. Seasonal conditions seem to influence greatly the reaction of the varieties towards the disease. On account, however, of the meager observations made in the field by the writer, the data on relative susceptibility of varieties to the disease is necessarily provisional.

In Louisiana,(11) red rice and Honduras especially the latter were reported susceptible to it, and certain rice millers claimed to have seen it, but rarely, on Japanese rice. In India,(5) its sporadic outbreaks show no respect for any particular variety.

While the rice bunt is a grain-infesting disease, it thrives well on the starchy portion or water absorbing constituent of the kernel, and seems more prevalent on varieties håving a more or less chalky endosperm, characterized generally by the presence of a big white belly, or white opaque area in the center, it seems interesting to find what connection, if any, the disease has on the texture or major constituents of the kernel, in such varieties as those having a somewhat translucent, flinty or corneous endosperm, like Elon-elon, for example, and those which are partly chalky and brittle, like Sipot, or those uniformly chalky and opaque. In the absence of analysis as to the quantitative difference of these constituents in the types of kernels described, it is premature to state anything as to their possible relationship with the black smut fungus.

The viability of the seeds of the different varieties seems also a limiting factor in the prevalence of smut, as those which germinate rapidly would likely outgrow the effects of the fungus.

The difference in succulence in the stems of varieties might have also some relation with their resistance or susceptibility, as the less sappy varieties would probably retard, if not inhibit altogether the entrance and normal development of the pathogene. And just how upland rice would react to this disease nothing definite is yet known.

PREVENTIVE OR CONTROL MEASURES

While the disease is not considered at present of major importance, as its distribution and prevalence in the Philippines is not definitely known, it seems advisable to have some sort of remedy at hand which can be resorted to should the necessity arise. As with almost any harmful and disastrous thing under the sun, the problem lies not so much in combating the disease as in preventing it, to do which certain steps may be suggested.

To control the disease effectively, one needs to be familiar with its symptoms and signs. Familiarity with the disease is an important consideration because the disease is not easily detected in the field and may be confused with other grain diseases. It is also important to have a knowledge of the mode of infection and the factors favoring it, as well as the cause, and the agencies of dissemination.

Without going into details, the principal preventive measures may be summarized as follows:

As the disease is carried by the seeds attention cannot be too strongly directed towards the careful selection of seeds derived from healthy plants. As far as possible, procure seeds from a healthy crop or from a locality where the disease is not known, taking care not to contaminate the selected seeds through the use of threshing machines, sacks or other containers. It is always advantageous to sow well-developed, smut-free grains, as they will produce the best plants, and before sowing, always to remove chaffy or light grains, weed seeds and other foreign materials. Besides, this will save any extra outlay for fungicides, or for more seeds to the hectare due to decreased rate of germination and may be for re-sowing.

Another means of control that might offer considerable promise at present would be local quarantine, or prohibiting the export of seeds from infected localities, with thorough inspec-

tion and treatment of seeds for planting purposes to obviate the risk of disseminating the disease, and to prevent its development in large areas.

As infection apparently takes place during the early stages of seed germination, the application of formalin, that is, 1 part formalin to 50 parts water at the rate of 2 quarts (1 quart equals 946.5 cubic centimeters) per square foot of soil, to the seedbeds a week or more before seeding would probably be beneficial also.

In serious infections, or if no sound seeds are available, the infected grains should be separated from uninfected ones by pouring them into water portion by portion, stirring vigorously so as to float the lighter, infected grains which should then be skimmed off. The wet grains should be spread thinly and dried in the air at once, and should not be used for seed. To insure that no traces of the smut are left in the seeds, it is better to treat them with one of the recommended fungicides before sowing.

Rice seeds with spores adhering to the glumes may be disinfected. In South Carolina,(11) where it is claimed the rice bunt was stamped out in four years after its appearance, the treatment followed was pouring the infected grains into water and skimming off the floating or light grains and then soaking the seeds for a day, or for twenty-four hours in a solution of 1.5 pounds of liver of sulphur (potassium sulphide) in 25 gallons of water, or soaking for two hours in a 2 per cent solution. Owing to the close similarity of this disease to the wheat bunt, it is probably amenable to seed treatments that have proved successful for the prevention of the latter, such as the copper carbonate dust treatment, formaldehyde treatment, and the use of ceresan, dubay, semesan, or various other organic mercury compounds on the market. But these chemical treatments are not recommended universally, except in serious infections, for they are expensive and have to be given every year; irksome, because of the difficulties involved in handling; and highly poisonous. Seeds treated with these chemicals should not be used for food because they are poisonous. Haskell et al.,(12) in connection with wheat bunt, recommended the following seed treatments:

Copper carbonate dust treatment.—Use 2 ounces (1 ounce equals 28.3495 grams) of 50 per cent grade or 3 ounces of 18 to 20 per cent grade applied to each bushel (equals 35.2 liters) of seed with a home-made revolving barrel duster. See to it that all the seeds are covered completely by the dust.

Formaldehyde treatment.—Soak the seeds in a solution made up of 1 pint (equals 0.473 liter) commercial formaldehyde to 40 gallons (1 gallon equals 3.785 liters) of water, no more and no less, using containers that will float the light infected grains to the surface where they can be skimmed off. Formalin-treated seeds should be sown immediately in wet soil. Care should be taken that no reinfection takes place after treatment.

Organic mercury compounds.—Uspulun or germisan 0.25 per cent solution for thirty minutes, which afforded effective control of wheat bunt, according to Heald,(13) may also be employed. These modern compounds of organic mercury should prove wonders as seed disinfectants as they are generally considered to give perfect protection and at the same time maintain the vitality of the seeds and stimulate the growth of the seedling.

Seed treatments, however, although generally effective are of no avail if the details are not followed carefully and persistently. Suitable equipment and reliable chemicals are also necessary adjuncts.

Caution.—These chemicals are poisonous and have to be handled with great care; besides, formalin irritates the eyes. No treated seeds should be used for food or fed to animals. When using copper carbonate, a dust mask should be worn by the operator.

The hot-water treatment is another method of destroying seed-borne organisms, but it is tiresome and likely to fail unless the temperature recommended is kept constant. Smutty seeds are dipped in hot water at 53° C. for ten minutes, or 54° C. for five minutes, if the seeds were soaked previously in water for a day. Hot water destroys the spores of all smut diseases, but if the directions are not adhered to closely it may injure the seed and the percentage of seed germination may be lowered.

And while seed treatment is effective and a recommended practice, it does not totally shield the plants from being attacked through infected soil; which makes the growing of resistant varieties or strains having commercial importance, or attractive culinary qualities,(6) advisable. This is the cheapest method and usually gives more lasting results, as one does not have to give tedious treatments year after year, unless the stability of the organism changes; that is, unless the problem is complicated by the production of the so-called physiologic forms.

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[6] The best index for their merits in the rice trade, but this is generally regarded as a secondary consideration in rice production.

To prevent the probable occurrence of alternate hosts, clean culture should be the rule.

Rice should not be followed by rice in fields where the black smut occurred the preceding year. To do so is to invite loss. How long the period of cropping should last is not definitely known and therefore no general recommendation can be given.

It is not safe to feed bunted rice to animals, such as fowls, pigs, etc., even though it may have little or no ill effect on them, because they are liable to scatter the spores to non-infected fields.

SUMMARY

The black smut, or bunt, of rice seems to have been introduced from Japan through the importation of seed rice, and its actual appearance in the Philippines is here reported for the first time. Although an article on rice diseases appeared in print in 1926, this was a compilation only and the circular on the subject was intended mainly as a warning to Philippine rice growers.

The disease is present in many important rice-producing countries of the world. Its distribution in the Philippines is not definitely known, as no systematic survey has yet been made. It is not considered a serious disease of rice, yet at times it is capable of causing considerable damage. It not only has a retarding influence on the growth and a pronounced effect on the yield but also may reduce the quality or lower the market value of rice.

The disease is not readily recognized in the field and can only be detected when the panicles mature by the presence of black spores usually massed towards the tips of the grains. The blackened grains are distributed irregularly either singly or in groups among normal grains. Occasionally some of the infected grains show slight enlargement or separation of the tips. In exceptional cases a sort of beaklike or inverted spurlike structure may be seen extruded through rupture on the keel of the larger glume or lemma, a characteristic feature which heretofore has not been observed in connection with rice bunt.

Internally the affected grains are partly or wholly replaced by a sooty-black, pulverulent mass of spores, covered with a saclike, semi-transparent cuticle. This is the surest indication of the disease.

The gross symptoms as a result of field and laboratory observations, as well as the distinctive characteristic features of the causative fungus have been described in detail and illustrated. Morphologic examinations revealed that the spores are almost

exactly like those described by other authors with respect to color, size, shape, and surface characters. The conclusion is therefore drawn that the black smut fungus found on rice in the Philippines is identical with *Tilletia horrida* Tak.

Under controlled conditions the disease was reproduced from seed-borne spores. Infection took place apparently in the early stage of seedling development. When infected seeds were planted, on germination the infection threads penetrated the tissues of the young shoot and grew upward with the vegetative tissues of the host. Usually the disease causes slight interruption in the host cells that no external signs become perceptible, but that this disease is systemic cannot be doubted.

It is clear from the results obtained that black smut infection may cause the shortening of the culms of rice, manifesting itself at an early stage of development of the plant and a subsequent reduction in grain yield and in straw. It has not been possible, however, to determine definitely what reaction it would have under different environmental conditions and on other host varieties.

The virulence of the disease is especially dependent upon climatic and other environmental factors. Under favorable conditions the degree of infection is materially increased, while under adverse conditions even plants from infected seed may escape the disease.

Field observations seem to indicate that the time of planting influences bunt infection. There is sufficient observational evidence to substantiate this point, showing that susceptibility is more pronounced when rice is planted during the dry season under irrigated conditions than in the regular rice season, which is probably accounted for by the temperature and moisture conditions which normally prevail during summer.

The disease is seed-borne by adherent spores on the outside of the grains and by those produced within the grains. It is spread by soil infection, by planting spore-bearing seeds, and by the mixing together of diseased and disease-free seed in the threshing or in winnowing. Spores may be scattered by the use of contaminated bags, sacks or other containers, by contact of diseased and healthy panicles while yet in the field, by the agency of the wind, perhaps, and by contaminated bran or rice which has been fed to farm animals, such as pigs, fowls, etc.

Artificial infection of rice panicles at different stages of development proved futile but further experiments simulating natural conditions seem in order.

The disease has thus far been found only on irrigated rice. Varieties seem to differ to some extent in their liability to it; the early varieties, especially when planted during the dry season have shown more susceptibility than the late varieties. There seems to be a relation between the disease and the rice kernels having an opaque, chalky or brittle endosperm and those having a translucent, corneous or flinty endosperm.

The viability of the seeds of different varieties seems also a limiting factor in the prevalence of smut, as those which germinate rapidly would likely outgrow the effects of the fungus.

The per cent of smut appearing in the crop is influenced by various cultural practices, but great importance is to be given to the time or season of planting.

The control measures for the disease are discussed.

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ILLUSTRATIONS

PLATE I

Rice spikelets affected with black smut caused by *Tilletia horrida* Tak. At the bottom are a few normal grains on the upper portions of the spikelets. About × 7/8.

PLATE II

Portions of rice panicles showing conspicuous deformity of the grains as a result of serious black-smut infection. Note the inverted spurlike structure extruded by the bursting of the keel of the lemma or larger glume. Approximately × 2.

PLATE III

Enlarged view of diseased and normal rice grains of same variety. Rows *a* and *b*, grains and kernels almost thoroughly blackened with spores and larger than the normal, showing the spurlike outgrowth; row *c*, smutted grains with the lemma removed, showing more or less varying degrees of infection; row *d*, infected grains with the apices forced slightly apart by hypertrophied ovaries; rows *e* and *f*, kernels exhibiting varying degrees of infection and the black masses of spores visible through the thin membrane of shriveled ovaries; and rows *g* and *h*, normal grains and kernels. About × 2.3.

PLATE IV

[Camera-lucida drawings by the author × 876]

FIG. 1. Immature, hyaline spores of *Tilletia horrida* showing shrunken condition or irregularity of shape and arrested development due to overcrowding or to lack of nutriment.

2. Young hyaline spores showing peripheral thickening, remains of sporulating hyphae, and granular cell contents.
3. A hyaline spore showing no contents or spinous wall-projections.
4. A subhyaline spore showing the arrangement of rudimentary, blunt wall-projections and their reticulous formation. The interspaces between the spinous projections are clear and the projections are somewhate opaque.
5. Older spores, less opaque and yellowish when seen through transmitted light, showing well defined peripheral projections. Note that one of the spores still show the gelatinous envelope and the short remains of sporulating hypha.
6. *a*, A mature, opaque, dark-colored spore; *b*, bits of hyaline mycelium found mixed with spores; *c*, pieces of brownish, septate fungus filaments also found mixed with them.

PLATE V

FIG. 1. A photomicrograph of spores of *Tilletia horrida* to show different stages of development. The surface appears tuberculate but actually the reticulate markings are the irregularly polygonal bases of the spinelike protuberances. The smooth-walled spores are hyaline and immature and the light-colored spores are yellowish maturing spores. Note the curved spinous projections. Surface view, × 380.

2. Sectional view of same spores photomicrographed to show clear outlines or echinulations or numerous curved projections from the epispore. About × 390.

PLATE VI

FIG. 1. Twenty-five-day old rice seedlings produced from plump or lightly bunted seeds, showing marked evidence of dwarfing and chlorotic or pallid condition of the leaves.

2. Rice seedlings of same age photographed immediately after the smutted plants were taken, at same focal distance. Note that these healthy seedlings grown from healthy seeds, despite crowded condition, proved fast growers. The reflected light at the time of photographing spoiled somewhat the picture as if chloritic leaves were also present, although there was absolutely no evidence of it.

PLATE VII

The three pots to the left contain maturing plants transplanted from seedlings obtained from the infected pot shown in Plate VI, fig. 1. Note the stunting of the plants in these pots in contrast with the plants produced from normal seedlings shown in the pot at the extreme right.

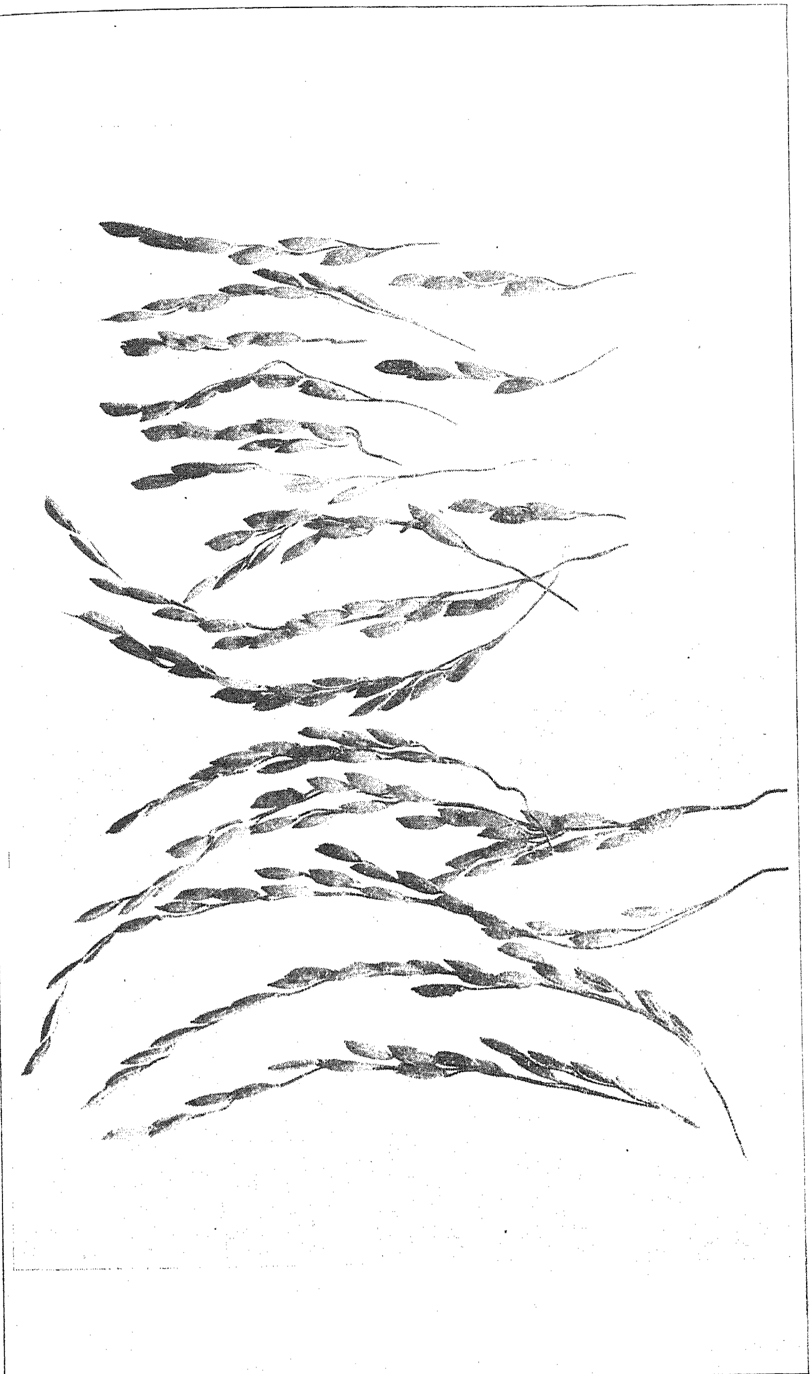

PLATE I

PLATE II

a
b
c
d
e
f
g
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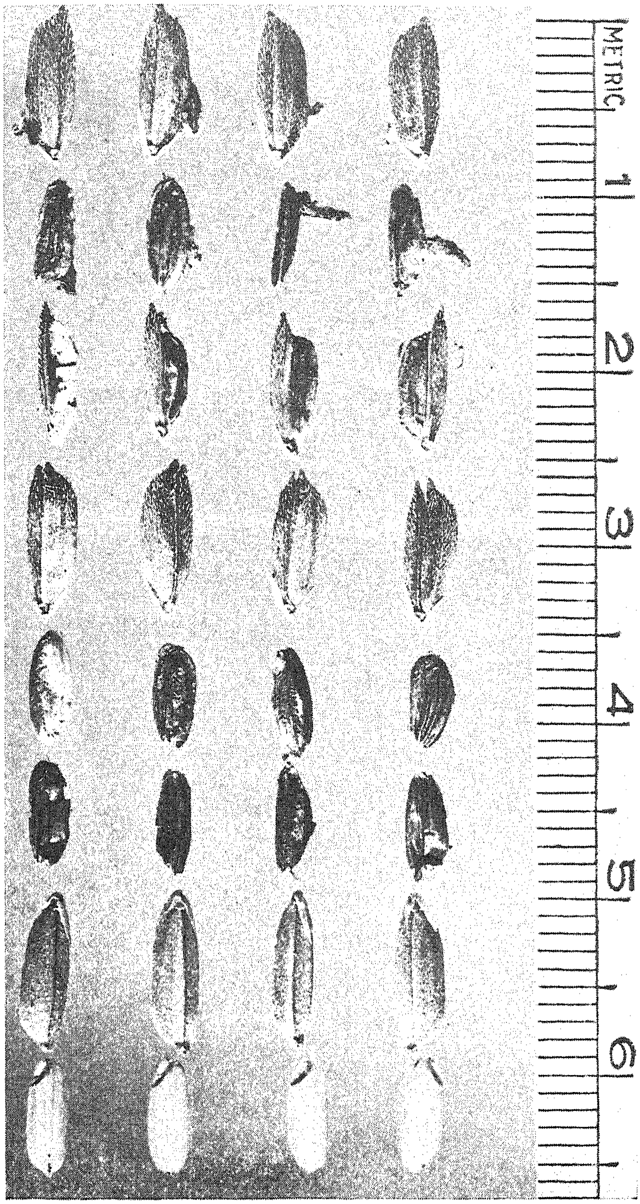
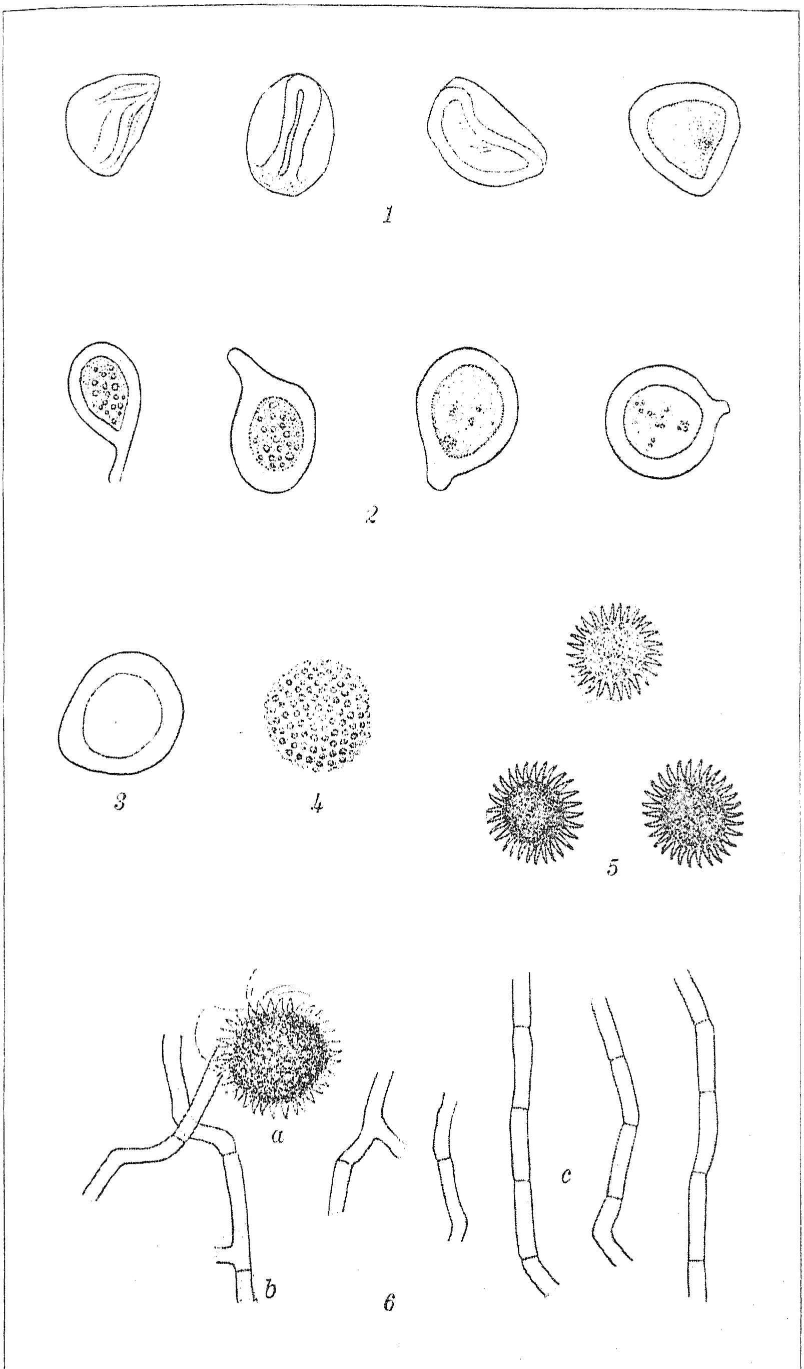


PLATE III



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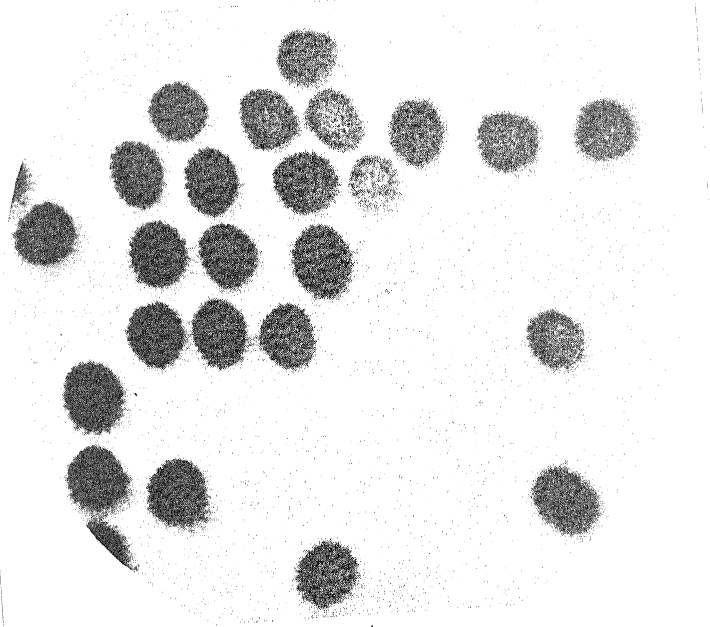

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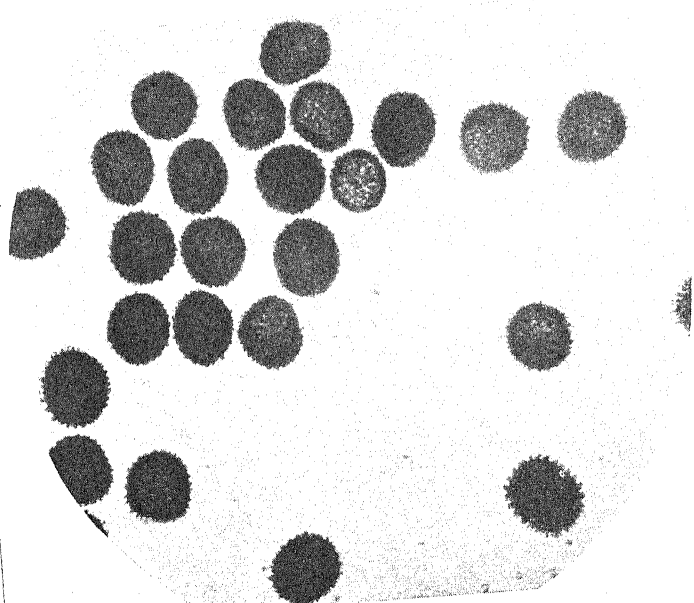

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PLATE V

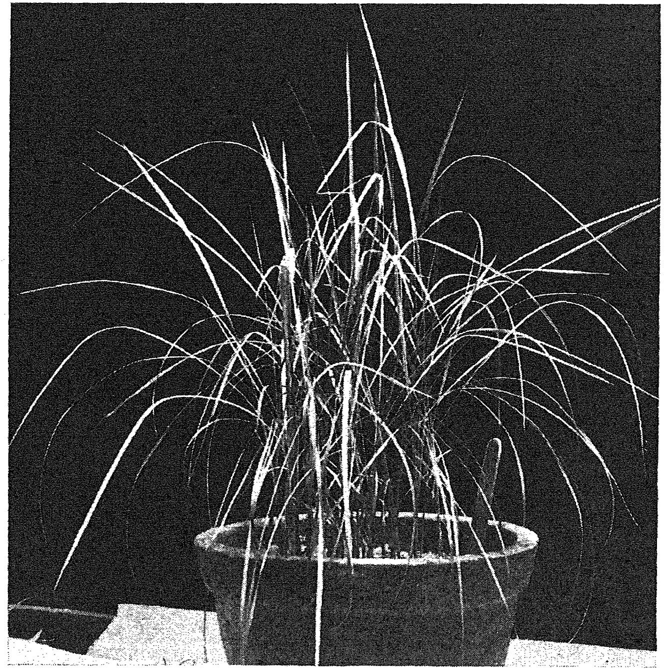

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PLATE VI

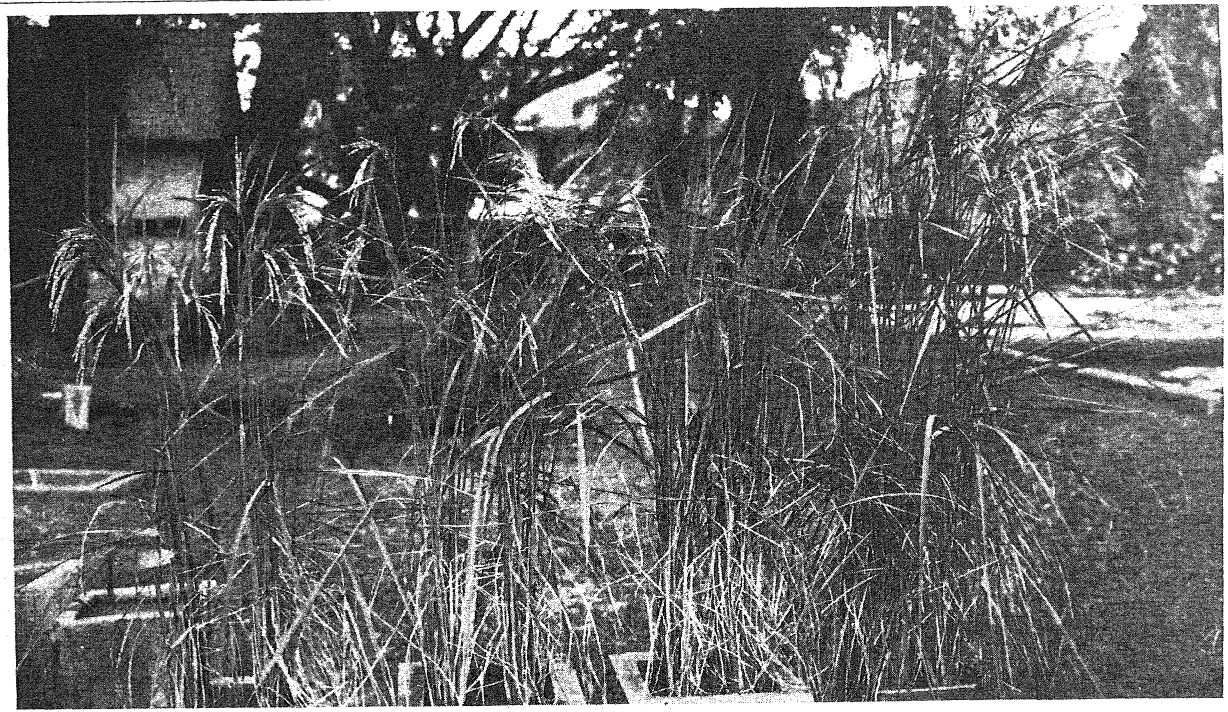

PLATE VII

POSSIBILITIES OF DEVELOPING THE CASSAVA INDUSTRY IN THE PHILIPPINES

By F. T. ADRIANO

Chief, Agricultural Chemistry and Soil Technology
Bureau of Plant Industry, Manila

THREE PLATES AND ONE TEXT FIGURE

Cassava, scientifically known as *Manihot utilissima* Pohl., is called by different names. In the Philippines, it is commonly known as *balangay* or *kamonteng kahoy* in the Visayas, *bangala* in Lanao, *pangina* or *bingala* in Bukidnon, *kamote Moro* in the Ilocos, *pangi-kahoy* or *kamote-kahoy* in Sulu, *balinhoy* or *kamoteng kahoy* in the Tagalog provinces, *kamunte-kayo* in Zamboanga, *malamboanga* in Palawan, *padpadi* in Mountain Province.

In Malaya and in the Dutch East Indies, it is commonly known as *tapioca, cassava, mandioca,* and *manioc.* However the term "*tapioca*" usually refers to different forms of cassava products. In Cuba it is known as "yuca," a name of Brazilian origin.

While cassava has been grown in the Philippines for a long time, the plant having been introduced by early Spanish colonists, its cultivation has not been as extensively carried on as in other tropical countries.

According to the Division of Statistics of the Department of Agriculture and Commerce, the area under cultivation, production, and value of cassava raised in the Philippines in recent years, were as follows:

TABLE 1.—*Cassava statistics for the Philippines 1928–1932*

Year ending June 30	Cassava				
	Area cultivated	Production	Yield per hectare[a]	Average price[b]	Total value
	Hectares	*Kilos*	*Kilos*	*Peso*	*Pesos*
1928	16,154	23,427,500	1,450	0.02	521,200
1929	14,906	19,870,690	1,333	.02	428,630
1930	15,476	22,971,900	1,484	.02	502,570
1931	14,583	25,920,500	1,777	.03	673,330
1932	14,785	35,493,800	2,401	.02	766,590

[a] These figures are too low. [b] These figures are too high.

TABLE 2.—*Cassava; area under cultivation, production, and value for the year ending June 30, 1932*

Province	Area under cultivation	Production	Average		Value
			Yield per hectare	Price per 100 kilos	
	Hectares	*Kilos*	*Kilos*	*Pesos*	*Pesos*
Abra	......	......	......	......	......
Agusan	40	92,300	2,307	2.35	2,170
Albay	435	1,388,300	3,191	2.48	34,420
Antique	151	337,700	2,236	2.82	9,520
Bataan	50	108,400	2,168	2.24	2,430
Batanes	......	......	......	......	......
Batangas	225	446,200	1,983	3.48	15,530
Bohol	907	2,691,300	2,967	2.00	53,840
Bukidnon	211	709,600	3,363	1.82	12,930
Bulacan	......	......	......	......	......
Cagayan	3	8,100	2,700	2.22	180
Camarines Norte	240	371,000	1,546	2.18	8,100
Camarines Sur	255	687,100	2,694	2.68	18,390
Capiz	1,124	3,738,400	3,326	2.16	80,650
Cavite	36	65,900	1,830	2.87	1,890
Cebu	1,182	2,652,400	2,244	2.47	65,410
Cotabato	238	670,400	2,817	2.72	18,210
Davao	158	407,900	2,582	2.70	11,000
Ilocos Norte	234	435,700	1,862	2.95	12,860
Ilocos Sur	55	114,800	2,087	3.55	4,080
Iloilo	188	338,000	1,798	2.76	9,320
Isabela	52	129,600	2,492	2.34	3,040
Laguna	67	134,700	2,010	3.22	4,340
Lanao	991	1,959,000	1,979	1.22	23,830
La Union	392	1,180,700	3,012	2.85	33,660
Leyte	255	611,600	2,398	1.80	11,040
Marinduque	78	170,500	2,186	1.65	2,810
Masbate	193	582,300	3,017	1.51	8,800
Mindoro	45	101,400	2,253	2.46	2,500
Mountain	15	43,000	2,867	1.44	620
Nueva Ecija	136	305,900	2,249	2.80	8,560
Nueva Vizcaya	33	70,800	2,145	2.37	1,680
Occidental Misamis	179	336,300	1,879	2.21	7,430
Oriental Misamis	26	59,100	2,273	1.56	920
Occidental Negros	197	555,300	2,819	2.32	12,870
Oriental Negros	1,150	2,526,400	2,197	1.99	50,400
Palawan	275	546,200	1,986	1.77	9,660
Pampanga	7	20,100	2,871	2.79	560
Pangasinan	395	989,600	2,505	2.13	21,090
Rizal	34	73,100	2,150	2.12	1,550
Romblon	232	764,000	3,293	1.62	12,410
Samar	1,048	2,031,100	1,938	1.97	40,120
Sorsogon	1,049	1,970,400	1,878	1.72	33,890
Sulu	748	1,962,800	2,624	2.44	47,940
Surigao	138	337,200	2,443	2.02	6,800
Tarlac	29	51,500	1,776	2.80	1,440
Tayabas	592	1,409,000	2,380	2.31	32,510
Zambales	139	250,100	1,799	1.98	4,950
Zamboanga	558	1,058,600	1,897	1.91	20,240
Philippine Islands	14,785	35,493,800	[a] 2,401	[b] 2.16	766,590

[a] This figure is too low. [b] This figure is too high.

In Malaya, the Dutch East Indies, Brazil, Cuba, and other countries cassava forms an important if not the main article of diet. Cuba in 1932, in order to encourage the development of the cassava industry, passed a law making it obligatory for baking establishments to mix with wheat flour cassava flour

to the extent of not less than 10 per cent nor more than 40 per cent in the preparation of bread and other bakery products. It might be of interest to quote hereunder that law.

LEY DECLARANDO OBLIGATORIO EL USO DE LA HARINA DE YUCA EN LA CONFECCIÓN DEL PAN

(Publicada en la Gaceta Oficial de 2 de enero de 1932)

SECRETARÍA DE AGRICULTURA, COMERCIO Y TRABAJO

GERARDO MACHADO Y MORALES, Presidente de la República. Hago saber: que el Congreso ha votado y yo he sancionado la siguiente,

LEY:

ARTÍCULO I.—A partir de la promulgación de esta Ley, quedan obligados los dueños de panaderías, a emplear en la confección de sus productos, tales como pan, galletas y sus similares un diez por ciento de harina de yuca, sin exceder de un cuarenta por ciento.

ARTÍCULO II.—Los infractores de la disposición contenida en el artículo anterior, serán multados desde treinta y un pesos a cien pesos por la primera infracción, y los reincidentes con pena de arresto de sesenta días a ciento ochenta, siendo competentes los Jueces Correccionales para imponer esos correctivos.

ARTÍCULO III.—Queda autorizado el Poder Ejecutivo para dictar el Reglamento para la mejor aplicación de esta Ley.

ARTÍCULO IV.—Esta Ley regirá a los diez y ocho meses de su publicación en la Gaceta Oficial de la República.

Por tanto, mando que se cumpla y ejecute la presente Ley en todas sus partes.

Dada en el Palacio de la Presidencia, en la Habana, a treinta y uno de diciembre de mil novecientos treinta.

(Fdo.) GERARDO MACHADO,
Presidente

(Fdo.) DR. E. MOLINET,
Secretario de Agricultura, Comercio y Trabajo

Comenzará la vigencia de esta Ley el día 2 de julio de 1932.

In Brazil, in spite of the fact that the cultivation of cassava is already well established, the Government, realizing its great commercial value and importance as an article of diet, and bent on giving this industry an additional measure of protection and encouragement, passed a resolution in 1922, authorizing the Ministry of Agriculture and Commerce to grant easy installment loans at 6 per cent interest under certain conditions, to farmers or corporations who would engage in the erection of factories.

If similar Government protection or encouragement is adapted here, the possibilities of developing the cassava industry would seem great.

282435——3

To show the importance of and the need of developing the cassava industry here, and that every effort in this direction should be fully encouraged, it is only necessary to point out the heavy importations annually of wheat flour and starch. Wheat flour is also mentioned because of the possibility of displacing a certain proportion of it in the preparation of bread and other baking products by cassava flour.

TABLE 3.—*Quantity and value of starch and wheat flour imported into the Philippines from 1930 to 1933*

Year	Starch		Wheat flour	
	Quantity	Value	Quantity	Value
	Kilos	*Pesos*	*Kilos*	*Pesos*
1928	4,235,567	508,868	75,881,252	10,650,603
1929	3,261,105	441,063	77,595,086	10,120,155
1930	6,249,498	928,559	70,538,720	8,982,329
1931	5,948,222	702,917	79,013,252	6,429,237
1932	4,847,977	444,543	69,224,672	4,903,878
Average	4,908,474	605,190	74,450,596	8,217,240

The following table will show the commercial value and variety of products of cassava exported from Java for 1932.

TABLE 4.—*Principal exports of cassava or tapioca products from Java in 1932*

[Weights in 100 tons.]

Destination	Gaplek	Gaplek meal	Tapioca flour	Tapioca flake	Tapioca pearl
U. S. A.		24	526	13	21
Denmark		196			
Norway		169			1
Japan	184	12			
Belgium and Luxemburg		60	28		10
Netherlands		15	19	4	6
United Kingdom	4	121	89	33	36
Germany		2			1
France			4		
Spain	217			1	
Sweden	4				
Australia					3
Italy		221	2		
China			20		2
British India			20		22
Penang					
Singapore			14		
Indo-China			1		
Hongkong			46		1
Philippines			21		1
Canada			1		5

There are numerous varieties of cassava in cultivation at the present time most of which are of foreign introduction and many more are being discovered as a result of crossing. However, in Java, it is claimed that more than two dozen varieties are considered of commercial value. In the Philippines also many varieties are known. Cassava can be classified into the so-

called "sweet" or edible and "bitter" or poisonous varieties. Sweet or edible varieties are reported to contain from 0.014 to 0.042 per cent in the bark and from 0.003 to 0.015 per cent hydrocyanic acid in the edible portion and the "bitter" or poisonous varieties from 0.012 to 0.056 per cent in the bark and from 0.013 to 0.037 per cent of hydrocyanic acid in the flesh. The author has devised a rapid method of testing hydrocyanic acid in cassava tubers which is suitable for field tests. Reference to this article is given at the end of this paper.

For the manufacture of starch the bitter and high yielding varieties which are rich in starch are preferred. These latter varieties are less subject to the depredations of both men and animals. Table 5 gives the differences in composition of some important varieties grown in the Philippines. For other agronomical and botanical data, the reader is referred to either the Director of Plant Industry or the College of Agriculture.

CULTURE AND CHEMICAL COMPOSITION OF CASSAVA

Cassava can be grown in almost any kind of soil provided with good drainage, but soil that is light, sandy and well irrigated as well is considered the best.

The plant is propagated by stem cuttings usually 15 to 22 cm in length which are planted vertically after the soil has been properly prepared. The distance recommended for planting varies, but planting one meter apart each way, which will give 10,000 points to the hectare, is the method commonly practiced.

The cultivation should begin when the plants are about 30 cm high. Usually two to three weedings are sufficient, after which the plants will have covered practically the whole space, thus preventing the growth of weeds.

Depending on the variety, soil, and climatic conditions, the tubers are ready for harvest when they are about eight to fourteen months old. In other places the harvesting is not done even until as late as eighteen months after planting.

The yield per hectare of fresh tubers varies greatly, according to several factors, such as variety, soil fertility, climate, cultivation, age of plant, etc. In the Philippines it is reported that the average production is about 10 tons per hectare, although with proper seed selection, the right variety, and the use of good cultural methods, this yield can be raised considerably. In Java, yields as high as about 44 tons per hectare have been reported.

In Bataan and Zambales, the yield runs to 20 or more tons per hectare it is said. Assuming a yield of only 2 kilos per

tuber or hill or plant and 10,000 hills to the hectare when a 1-by-1 meter planting distance is followed, a yield of 20 tons per hectare can be obtained. Experiments, however, have shown that by proper methods of culture, it is possible to secure 3 to 4 kilos of tubers per hill thus giving a yield of 30 to 40 tons per hectare.

The author and his coworkers have analyzed many varieties of cassava; the average composition is given as follows:

	Per cent
Edible portion	81.40
Moisture	63.80
Ash	1.44
Proteins	0.96
Fats	0.26
Hydrocyanic acid	0.02
Crude fiber	0.85
Starch	27.65
Nitrogen free extract (carbohydrates)	5.04
Calorific value per kilo (calories)	1,403.00

Table 5 gives the yield per hectare and analysis of some important varieties.

TABLE 5.—*Yield of cassava per hectare and the chemical composition of some important varieties grown in the Philippines* [a]

Variety	Yield of tubers in tons per hectare			
	P. I.		Java	
	Tubers	Starch	Tubers	Starch
Mandioca Sao Pedro Preto [b]	38.5	....	44.79	11.92
Mandioca Basiacao	37.92	9.80	....	....
White Native	....	....	16.40	5.24
Red Native	23.78	7.63	....	....
Rough Internode	26.29	6.90	....	....
Baker	33.15	10.09	....	....
Colored or Red	27.43	9.16	....	....
Singkong Manis	27.18	6.17	....	....
Kapo Colorado	32.85	10.60	....	....

Variety	Chemical analysis (Results expressed in per cent)						
	Moisture	Protein	Fats	Ash	Carbohydrates		
					Crude fiber	Starch	Total
Mandioca Sao Pedro Preto [b]	59.68	0.57	0.35	1.25	0.87	31.89	32.76
Mandioca Basiacao	68.31	0.50	0.05	1.06	0.67	26.26	26.93
White Native	57.42	0.40	Trace	1.00	1.23	31.77	33.00
Red Native	59.81	0.42	Trace	0.95	0.90	30.96	31.86
Rough Internode	59.62	0.61	0.11	1.19	0.75	29.06	29.81
Baker	60.16	0.43	Trace	1.09	0.90	30.42	31.32
Colored or Red	56.45	0.60	Trace	1.22	0.69	33.39	34.08
Singkong Manis	60.39	1.38	0.13	1.48	1.11	26.38	27.49
Kapo Colorado	58.70	0.60	Trace	0.86	1.04	32.26	33.30

[b] Yield computed from experiments in Lamao and Los Baños. [b] Poisonous.

PRODUCTS OF CASSAVA

Cassava can be converted into a variety of products, the most important of which are given as follows:

Cassava flour.—In Malaya, the Dutch East Indies, Brazil, Cuba and other tropical countries, cassava flour is used in the preparation of many articles of diet.

Tables 6 and 7 will show the value of cassava flour for bread making as compared to wheat and other cereals:

TABLE 6.—*Chemical analysis of cassava and important cereal flours*

	Cassava	Corn	Wheat	Rice
	Per cent	*Per cent*	*Per cent*	*Per cent*
Moisture	10.75	13.41	13.65	13.12
Protein	0.87	7.56	12.35	9.85
Fats	1.19	2.79	1.75	0.88
Ash	1.24	1.78	1.81	1.51
Crude fiber	6.12	3.19	2.53	0.63
Carbohydrates	79.83	71.27	67.91	74.01

TABLE 7.—*Analysis of bread made from different flours*

	Wheat	Wheat with 25 per cent Cassava	Cassava
	Per cent	*Per cent*	*Per cent*
Moisture	25.19	20.84	24.15
Proteins	10.14	8.76	6.54
Fats	1.28	1.15	1.73
Ash	1.25	0.72	1.39
Crude fiber	1.60	1.19	0.72
Carbohydrates	60.54	67.34	65.83

Starch.—Cassava is an important raw material in the preparation of cassava starch, which is known in the Philippines as "gaogao." Cassava starch is used for laundrying purposes. It is also used in sizing yarns and cloths, in the preparation of the so-called British gums, dextrins, and pastes, and in the manufacture of confectioner's glucose, of which increasing quantities are annually used here. Of the last item alone more than 100,000 pesos' worth is annually imported.

In the manufacture of food, it is used in the preparation of custards, blanc mange, puddings, powder, macaroni, simolinas, and sauces, as a thickening agent in ice cream, and as fillers for various kinds of food products. It is also mixed with breakfast cereals.

Gaplek.—A malay term which refers to the dried and peeled or unpeeled roots of cassava. Gaplek is produced in large quantities in certain parts of Java and exported (see Table 4) to

Europe, Japan, and other countries as a raw material for the preparation of industrial alcohol and low-grade starch.

Pearl and flake tapioca.—These are used mainly for human consumption. Pearl tapioca is in the form of small spheres and consists of starch grains cemented together by the dextrin formed in the course of its manufacture. Flake tapioca consists of small spheres cemented together in an irregular manner. Both products are very pure carbohydrate foods, making delicate puddings, thickening for soups, and food for infants and the sick.

Feed for livestock.—Cassava forms a very satisfactory forage material and in combination with molasses and other foodstuffs to supply the nitrogenous and other necessary dietary elements, makes an excellent feed for livestock.

Dextrin.—As a source of dextrin, which is now used commercially as a substitute for the more expensive gum arabic and as a paste for book binding and similar uses, cassava starch is being used rather extensively.

Glucose.—Either in the form of a thick syrup or as a powder which is very much used in the confectionery industries.

Other uses.—It has also been used in the manufacture of beer, alcohol, vinegar, etc.

In view of the commercial importance of cassava starch and the possibilities of developing the cassava industry with starch as the main product, although other useful cassava products can be prepared later, I shall endeavor in the following pages to describe the processes used in its manufacture in an effort to arouse interest in the development of such a very important and yet neglected cassava industry in the Philippines.

THE MANUFACTURE OF STARCH FROM CASSAVA

In view of the great economic importance and value of starch, a description of the manufacture of this article from cassava should prove interesting and hence will be given hereunder.

Using the average quantity of starch imported into the Philippines as 5,000 tons and assuming that the average yield per hectare as has been reported here is 10 tons (although this yield should be considerably higher when proper cultural and manurial methods are followed) and assuming further that the average efficiency of the factory is 18 per cent recovery (although in Java 20 to 30 per cent are reported) it would require 28,000 tons tubers of cassava to produce this amount of starch and 2,800 hectares of land to produce this quantity of tubers. The

present production of tubers is mostly used for food or animal feed and very little is available for starch manufacture. There is therefore need of increasing the hectarage, improving the yield by use of right varieties and cultural methods, and employing more efficient methods of manufacturing the finished products.

A factory of 10 tons per day of twenty hours if it works on the basis of two hundred days in a year will require 2,000 tons tubers; and to produce the quantity of starch needed by the Philippines (5,000 tons), fourteen factories of the above capacity would have to be erected. The establishment of only six factories of this capacity as a start would mean employment to a large number of laborers, many of whom are at present idle. Besides it would develop a very important industry which has commercial possibilities.

In the Philippines, however, there are at present only a few starch factories, some of which are as follows:

1. Bataan Starch Factory, Samal, Bataan
2. Caosep Starch Factory, Naga, Camarines Sur
3. Philippine Starch and Sugar Factory, Janiway, Iloilo
4. Naic Starch Factory, Naic, Cavite

As far as we are aware only two or three factories are provided with the right kind of machinery and are actively functioning. The others, for some reason or other are not working. It is, however, reported that one of the causes for the failure of some factories to operate is the lack of sufficient raw materials, the factory having been erected before the plantation was established.

While cassava is grown throughout the Philippine Islands, there are only few plantations which are sufficiently large to supply the raw materials needed for a starch factory. There is need of starting plantations or getting planters under contract say for ten or five years to supply the raw materials, a contract similar to that used by the sugar centrals would seem satisfactory. While there are many small planters who are anxious to manufacture starch by the use of small machines, it is doubtful whether a factory of less than 5 tons per day can operate economically and produce starch which could compete with that coming from foreign countries.

There are a number of firms in Manila which can import starch-making machinery. Some of these are the Philippine Engineering Company, the Pacific Commercial Company, Fred Wilson Company, Smith, Bell and Company, Aguado Hermanos,

and others. These companies will be glad to furnish quotations to parties who are seriously contemplating the erection of starch factories.

Mr. Joaquin Joson, owner of the Bataan Starch Factory, has kindly placed at my disposal all data regarding his factory and using these and other data I have attempted to prepare a prospectus for starch factories of 5 tons and 10 tons of fresh tubers per day of ten and twenty hours' run. In the preparation of the prospectus which will be given hereunder, the year is considered as of only two hundred working days, although at other times of the year when the factory is not busy grinding cassava root, arrowroot or other tubers could be used as the raw materials in order to make the mill operate for as much of the year as possible and hence pay better.

In the following pages, I shall also attempt to describe the manufacture of starch from cassava using modern machinery.

Fresh tubers, which should not be more than 24 hours old, are delivered to the factory and immediately put into the washing machine, which is a large rotating perforated cylinder provided with squirt tubes so as to effect a thorough washing and cleaning of the tubers.

From the washing machine the clean tubers go directly to a grater that is operated at 2,000 revolutions per minute, thus reducing the tubers to a smooth pulp which is then pumped into a tank that is provided with an outlet tube. The grated pulp is treated with water and then led to twin circular oscillating sieves for washing out the starch. The strained liquid, consisting of starch in suspension goes to the repassing and refining sieves. From the oscillating sieves the residue or bagasse is recovered and this bagasse is sold to hog raisers at the rate of 10 centavos per kerosene canful.

From the refining sieves, the starch in suspension is led to what are known as starch tables. In the Mr. Joson's factory these tables are made of concrete. There are sixteen starch settling tables each measuring 25 cm wide by 24 meters long. In the starch tables, the water is run off at other end of the tables and the starch is allowed to settle therein. The settled starch is then sent to a sulphuring tank where it is treated with sulphurous acid prepared by burning sulphur in a sulphuretor. For 5 tons tubers a day, about 2 to 3 kilos of sulphur powder are burned.

From the sulphuring tank, the bleached starch is sent to another tank for washing out the excess acid. The washed

starch is mixed with a little water and then pumped up to a wooden tank, which is provided with a stirring device, thus keeping the starch in suspension, which is usually the consistency of thin condensed milk; and is dropped to a centrifuge that is used to separate the starch from the water adhering. From the centrifuge the starch that has been freed from as much water as possible, is conveyed to the drier. The dryer consists of a chamber provided with 260 sheets of plain 20-gauge galvanized iron on which the centrifuged starch is placed for drying. The dryer is provided with a big fan that drives the hot air in proper circulation, thus effecting efficient and rapid drying of the starch. From the dryer, the dried starch, which is obtained in lumps is sent to a grinder for grinding into a fine powder.

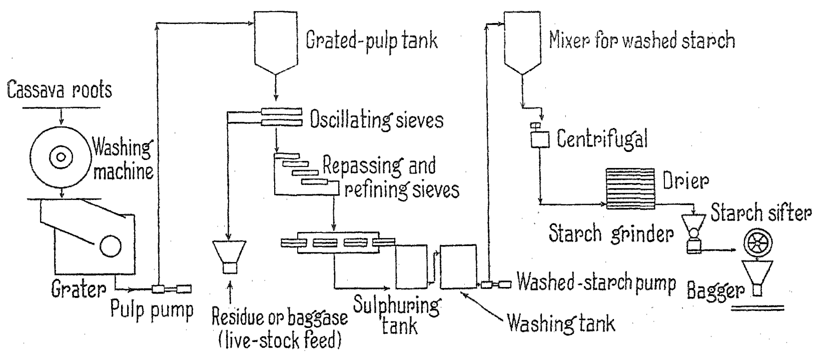

FIG. 1. Flow sheet for cassava-starch manufacture

The ground starch is dropped to a big shifter provided with silk bolting sieves of about 200-mesh. The shifted starch is then placed in jute bags. Usually the starch is bagged in a sack of 1 picul, or 63 kilos, although it is claimed that more profit is realized when the starch is bagged in kilo packages. However, the latter entails more attention and expenses.

The flow sheet for a cassava starch factory, here described, is shown in fig. 1.

COST OF MANUFACTURING CASSAVA STARCH

Using Mr. Joson's data and the current prices of the starch and the present scale of wages, I present a prospectus for a starch factory to take care of 5 tons and 10 tons of fresh tubers a day of ten and twenty hours, respectively. It will be seen that when properly managed the manufacture of starch from cassava is a paying proposition. Space does not permit the detailed discussion of all the operations and points that should

be considered. In the prospectus, it is only assumed that the factory buys fresh tubers from the planters around the factory, although it is reported that more profits can be realized if the factory conducts its own plantation. Interested parties who may wish to secure additional data will be furnished the information on application.

I. Prospectus for a cassava starch factory with a capacity of 5 tons of tubers a day (10 hours) when tubers are bought

		Pesos
A. EQUIPMENT		
(*a*) Complete starch machinery with 20-horse-power engine		24,250.00
(*b*) Galvanized iron, plain, 20-gauge, 260 sheets at 4 pesos		1,040.00
(*c*) Shed, starch tables, pipings, installation, etc		8,000.00
(*d*) One 2-ton delivery truck		1,750.00
		35,040.00
B. OPERATING EXPENSES		
(*a*) Tubers delivered to factory, 5 tons at 5 pesos	25.00	
(*b*) Fuel, 5 cart loads at 1 peso	5.00	
(*c*) Lubrication	1.00	
(*d*) Jute bags, 15 at 15 centavos	2.25	
(*e*) Light	1.00	
(*f*) Labor, 1 mechanic and 5 laborers	5.00	
(*g*) Overhead and incidental	3.00	
Total	42.25	
(*h*) Assuming 200 working days, at 42.25 pesos		8,450.00
(*i*) Transportation		1,000.00
(*j*) Registry, taxes, and propaganda		500.00
(*k*) Repairs and incidental		200.00
(*l*) Depreciation on equipment at 10 per cent		3,504.00
(*m*) Interest on operating expenses at 10 per cent		1,015.00
		14,669.00
C. INCOME		
(*a*) Starch, 14 piculs at 7 pesos	98.00	
(*b*) Bagasse, 150 5-gallon cans at 10 centavos	15.00	
	113.00	
(*c*) Assuming 200 working days, at 113 pesos		22,600.00
(*d*) Total expenses under I–B		14,669.00
Income		7,931.00

II. Prospectus of a cassava starch factory with a capacity of 10 tons of tubers in 20 hours when tubers are bought

		Pesos
A. EQUIPMENT. Same as I–A		35,040.00
B. OPERATING EXPENSES		
(*a*) Tubers, 10 tons at 5 pesos		50.00
(*b*) Fuel, 10 cart loads at 1 peso		10.00
(*c*) Lubrication		2.00
(*d*) Jute bags, 30 at 15 centavos		4.50
(*e*) Light		2.00
(*f*) Labor, 2 mechanics and 10 laborers		10.00
(*g*) Overhead and incidental		5.00
(*h*) Assuming 200 working days		16,700.00
(*i*) Transportation		2,000.00
(*j*) Registry, taxes, and propaganda		1,000.00
(*k*) Repairs and incidental		500.00
		20,200.00
(*l*) Depreciation on capital at 10 per cent		3,504.00
(*m*) Interest on expenses at 10 per cent		2,020.00
(*n*) Operating expenses		20,200.00
		25,724.00
C. INCOME		
(*a*) Starch, 28 piculs at 7 pesos	196.00	
(*b*) Bagasse, 300 5-gallon cans at 10 centavos	30.00	
	226.00	
(*c*) Assuming 200 working days, at 226 pesos		45,200.00
(*d*) Total expenses under II–B		25,724.00
Gross income		19,476.00

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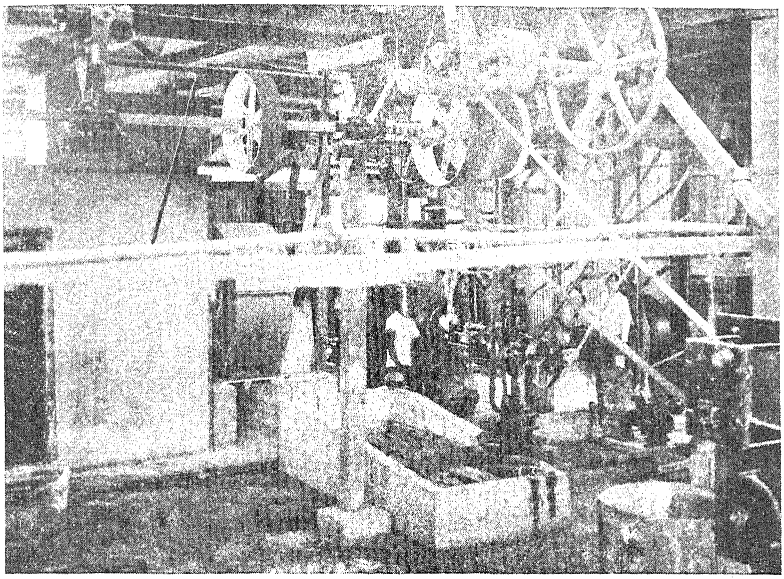
ILLUSTRATIONS



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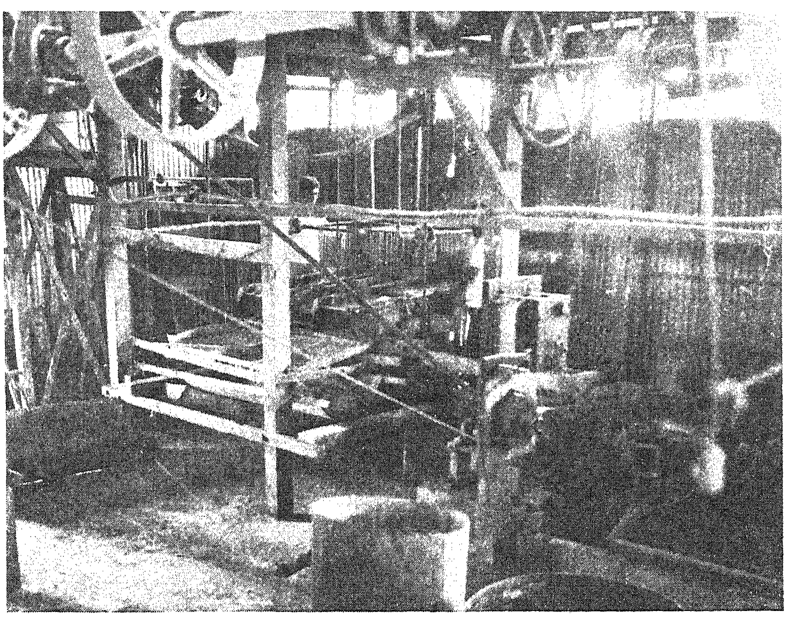

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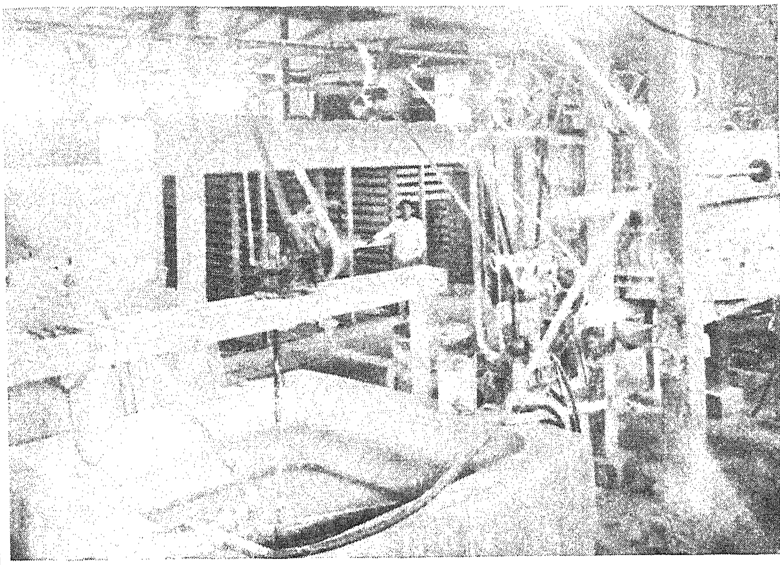

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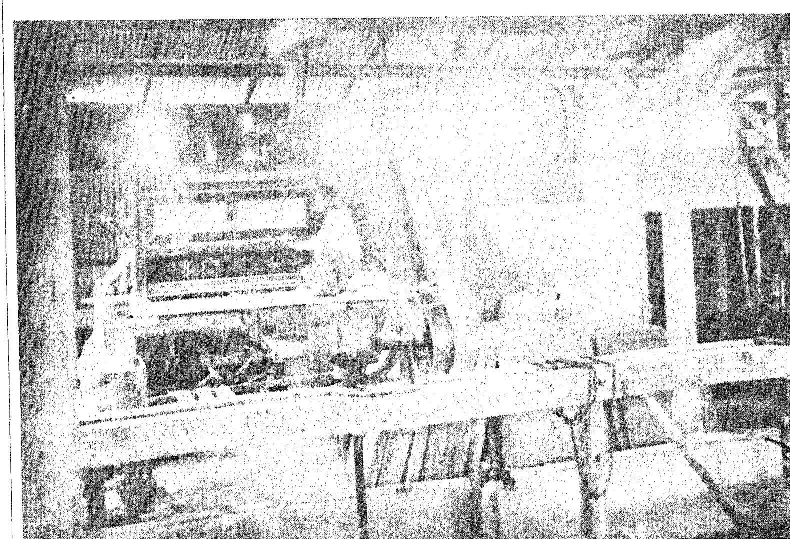

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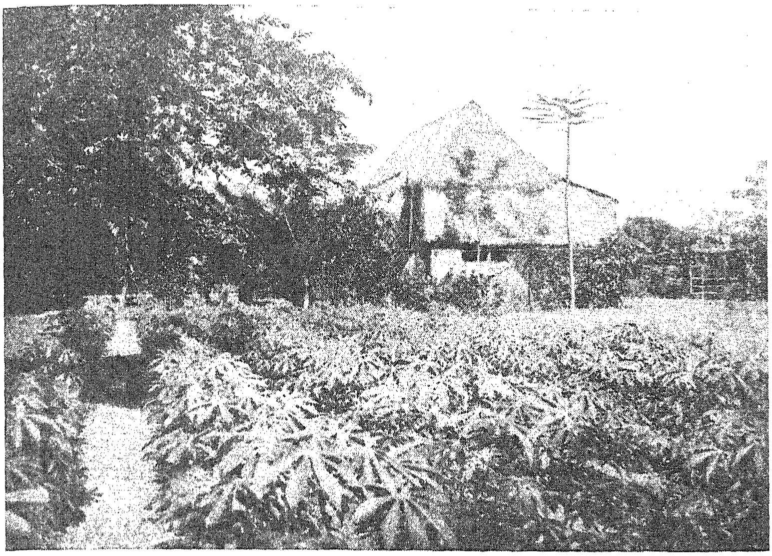

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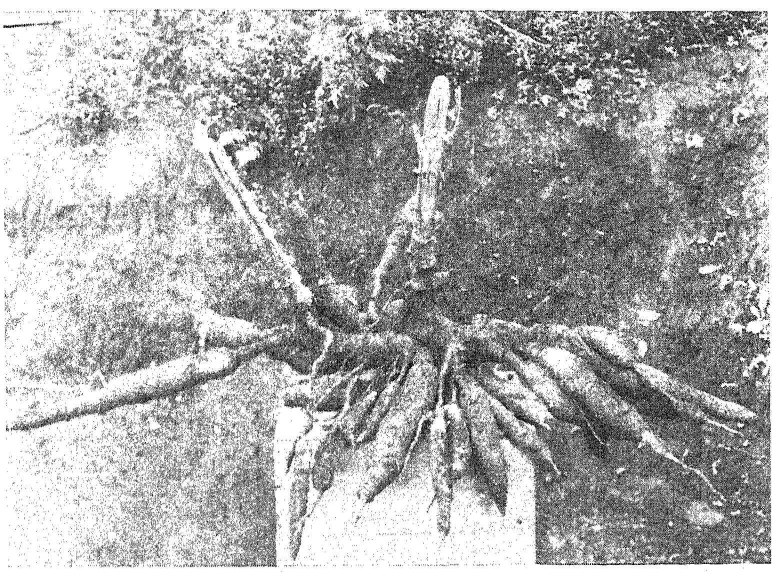

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PLATE III

INDEX

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CONTENTS

No. 1, First Quarter, 1933

[Issued December 5, 1933.]

No. 2, Second Quarter, 1933

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No. 3, Third Quarter, 1933

[Issued February 2, 1934.]

No. 4, Fourth Quarter, 1933

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